MM.

TRANSPORT CANADA
ROAD AND MOTOR VEHICLE SAFETY BRANCH

DRL AND HBL VALIDATION DESIGN COSTING STUDY

JAMES F. HICKLING
MANAGEMENT CONSULTANTS LTD.

JULY, 1983

CA1
DTC 121
83
D63
c.2

54

ERRATA FOR DRL/HBL REPORT

Page 11 2 paragraph: accommodate

Page 27 and 28: $W^2 = \frac{(P - P_2)^2}{4v^2}$

Page 38: 4.5 Data Editing - the Person-days were calculated using 3 days + 1 day per 5000 accident records

Library and Information Centre / Centre de Documentation (GSLA)
RECEIVED - REÇU LE
AUG 17 1983
Transport Canada / Transports Canada

TABLE OF CONTENTS

	PAGE
STUDY FINDINGS	1
1. INTRODUCTION	1
2. HARDWARE ANALYSIS	2
2.1 DRL Options Definition	2
2.2 Reduced Voltage Low-Beam Headlight Option	3
2.3 Retrofitted Running Lights	4
2.4 Increased Wattage Parking Lights	7
2.5 Constant-on Turn Signals	7
2.6 Option Trade-off Analysis	9
2.7 High-mount Brake Lights	11
3. OPERATIONAL OPTIONS	13
3.1 Hardware Installation Options	13
3.2 Sources for Field Trial Participants	14
3.3 Data Tracking	18
3.4 Duration of Trial	21
3.5 Geographic Distribution	23
4. SAMPLE SIZE ANALYSIS	25
4.1 Accident Reduction Rates	25
4.2 Level of Statistical Significance	29
4.3 Requirement for Sub-sample Results	30
4.4 Stratification of the Sample	31
4.5 Control Group	32

TABLE OF CONTENTS (Cont'd)

	PAGE
5. FIELD TRIAL COSTING	34
5.1 Task Breakdown	34
5.2 DRL Costing	42
5.3 HBL Costing	47
6. DESIGN RECOMMENDATIONS	50
6.1 DRL Trial	50
6.2 HBL Trial	52
7.0 REFERENCES	54

LIST OF FIGURES

2.1: Reduced Voltage Headlight Wiring Program	5
2.2: Retrofit Running Lights Wiring Progam	6
2.3: Parking Lights Wiring Program	8
2.4: DRL Hardware Comparison	10
4.1: DRL Sample Size Requirements	27
4.2: HBL Sample Size Requirements	28
5.1: Example of DRL Cost Estimate	40
5.2: Example of HBL Cost Estimate	41
5.3: DRL Program Costs By Sample Size	44
5.4: One Year DRL Trial Costs by Statistical Level	45
5.5: Two year DRL Trial Costs by Statistical Level	46
5.6: HBL Program Costs by Sample Size	48
5.7: One Year HBL Trial Costs by Statistical Level	49

TABLE OF CONTENTS (Cont'd)

APPENDICES

A HBL Descriptive Material

B Detailed Cost Estimates

C Cost Model Program Listing

STUDY FINDINGS

Based on the analysis contained in this report, the following general statements can be made concerning the design, sizing and costs of undertaking DRL and HBL field tests:

- the two experiments should not be combined due to the possibility of interaction of effects;
- the only two DRL systems which should be considered for experimental study are reduced voltage headlights or increased power parking lights;
- there is essentially no financial difference between these two DRL options ($15 vs $18/unit);
- the dual light HBL are currently commercially available;
- the sample size and costing analysis concluded that it would not be economically feasible to consider sub-national testing for statistical significance;
- the operational analysis indicated that insurance company co-operation and files are probably accessible and are the most cost-effective and reliable source for the required data;
- due to sample drop-out and tracking problems, a one year test program is recommended for both programs;

- commercial fleets are only feasible for smaller experimental fleets (less than 10,000) and thus are probably only viable for the HBL trial;

- based on nominal levels of statistical confidence the cost of a DRL test would be $800,000 to $1,000,000 and would require a total test fleet (both control and experimental) of 30,000 to 37,000 vehicles;

- the HBL trial would cost $210,000 to $270,000 and require a test fleet (control and experimental) of 5,700 to 7,300 vehicles.

1.0 INTRODUCTION

Over the past several years, there have been a number of evaluations and trials on the effectiveness of using daytime running lights (DRL) and high-mounted brake lights (HBL) on automobiles. In both cases, there have not been any large-scale field tests in Canada which would validate the countermeasure's effectiveness. Further, in the case of HBL, all the tests have used a single centre-mounted light and no evaluation of a dual light system (one on either side of the vehicle) has been undertaken.(1)

In order to undertake validation studies of both DRL and dual light HBL, Transport Canada commissioned this experimental design and costing study by James F. Hickling Management Consultants Ltd*. The objective of the study was to investigate the most suitable sample size, test fleet and accident recording methods to demonstrate DRL and HBL and to provide a cost estimate for the trial. The test was required to be regionally representative and representative of general driver profiles and exposures (e.g., taxi fleets to be excluded).

The study is divided into four sections:

- hardware analysis;
- operational issues;
- sample size analysis;
- cost estimates.

Because of the nature of design decision-making, a 'single-solution' can not be given in a report such as this. Rather, a range of costs is given which relates to a variety of fleet sizes and statistical levels of confidence. The reader can thus determine the program costs given the statistical constraints the user wishes to apply.

---

* formerly Hickling-Partners Inc.

2.0 HARDWARE ANALYSIS

2.1 DRL OPTIONS DEFINITION

In order to create a list of options for the daytime running light (DRL) configurations, a set of underlying assumptions had to be formulated which described the makeup of any DRL system. The following parameters were discussed and agreed upon with Transport Canada:

- the tested system must physically represent the expected regulatory system characteristics (i.e., be positioned near the outside of the vehicle, be front facing, etc.);
- the light intensity should be between 300 and 800 Candelas (cd);
- the light area should be at least 40 square centimetres;
- the side and rear marking lights should not be on during operation of the driving lights.

Given these basic parameters, the following systems were identified:

- reduced voltage low-beam headlights;
- retrofitted running lights;
- increased wattage parking lights;
- constant-on turn signals.

For each of these cases, an analysis of the wiring configuration was undertaken followed by an estimate of the component and installation costs.

2.2 REDUCED VOLTAGE LOW-BEAM HEADLIGHT OPTION

In this configuration, the low-beam headlight circuit would be reconfigured so that as soon as the accessory system is activated by the ignition switch, the headlight would come on. In addition, within the circuit would be a voltage reduction resistor to lower the intensity of the headlights to between 50% and 35% of their normal intensity. This intensity drop would require a reduction to 80% to 75% of normal voltage (12.8 volts).

All of the passenger cars currently in operation have generally similar electrical systems for the headlights (with the exception of a small percentage of old positive ground twelve volt and six volt systems). Furthermore, most cars have the ignition arranged so that the accessory system is shut off during engine starting. After the engine has been started, the accessory circuit is then reactivated. By tapping a headlight control circuit into the accessory system, the headlights will be triggered at any time when the accessories are on and avoid imposing a powerload during starting.

A generalized retrofit package was designed with the following design goals:

- circuit triggered by accessory system;
- voltage reducing resistor in line with the headlights to drop voltage to 80% to 75% of normal;
- wiring system modification does not require access to passenger compartment of vehicle but can be contained entirely within the engine compartment;
- an override shunt is activated when the full headlights are on.

The circuit designed is detailed in Figure 2.1 and is similar to one developed by the Illinois Institute of Technology (2).

A costing of the hardware required for this package was undertaken using estimates of wholesale level prices for the wire, solenoids and resistors. The component parts and packaging are estimated to cost less than $15 with an additional 15 minutes required for installation. Based on current labour rates of $20-30/hr., this brings the total cost for installation to approximately $20-23.

2.3 RETROFITTED RUNNING LIGHTS

This option contains similar hardware requirements as the reduced voltage low-beam option. However, it entails the use of lower wattage running lights which would be bolted to the bumper or front grill. In this case, no voltage reducing resistor would be required, and the result would be an overall lower power demand. The switching mechanisms would be exactly the same as for the reduced voltage headlight option. The wiring diagram is shown in Figure 2.2.

The cost of such a system is the same as the reduced voltage low-beam system minus the voltage reducing resistor ($5 to $6) but plus the additional cost of the driving lights. Currently available driving lights range anywhere from $15 to $40 for the type and quality required for this project. An average cost of suitable equipment is probably in the order of $30 retail. Installation time would be higher due to the requirement to bolt on the lights. An estimate of fifteen minutes per light was added to the 15 minute switch installation time making the total installation time 45 minutes. On this basis, the estimated cost of this system is $40 in hardware ($30 for lights + $10 for switch) plus forty-five minutes of labour at $20-30 per hour. The total cost is $55-65 per vehicle.

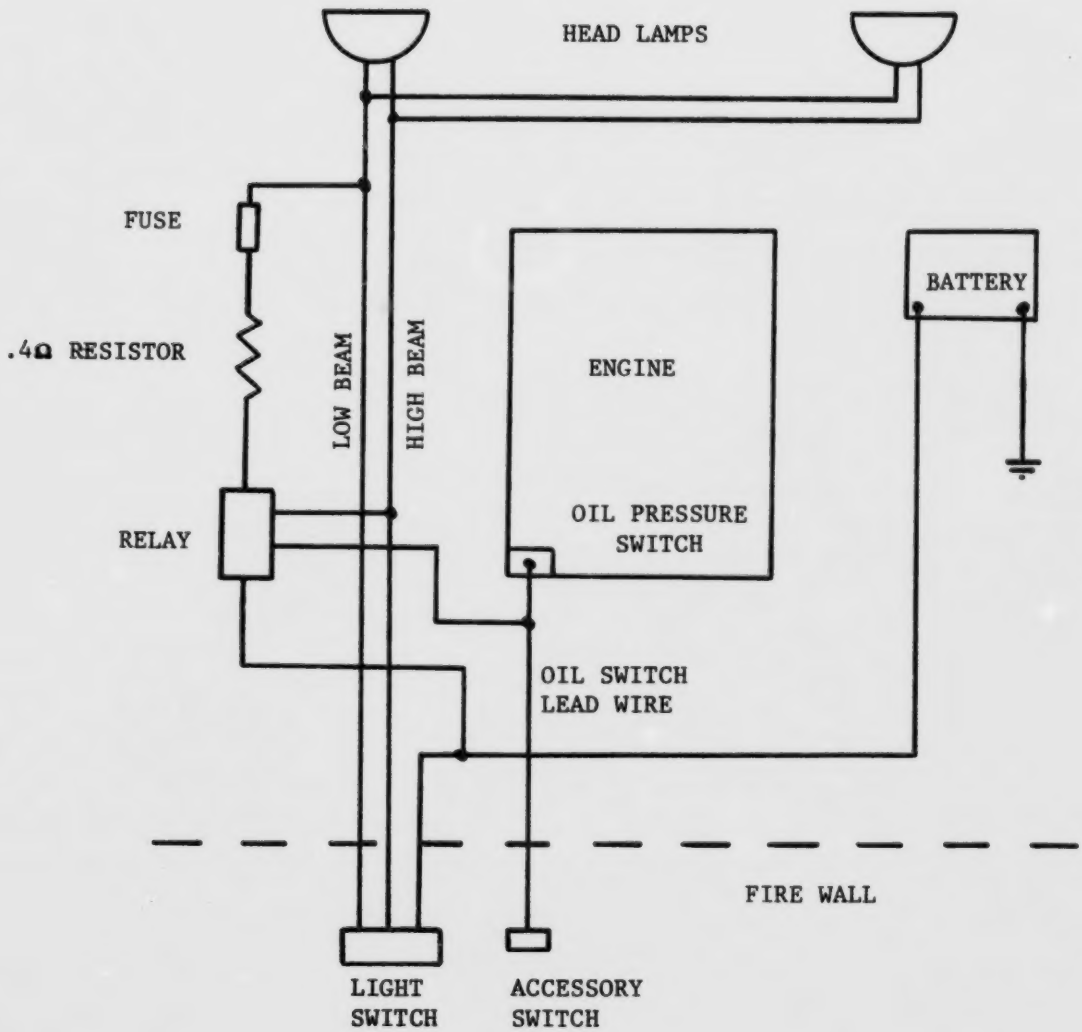


FIGURE 2.1: REDUCED VOLTAGE HEADLIGHT WIRING DIAGRAM

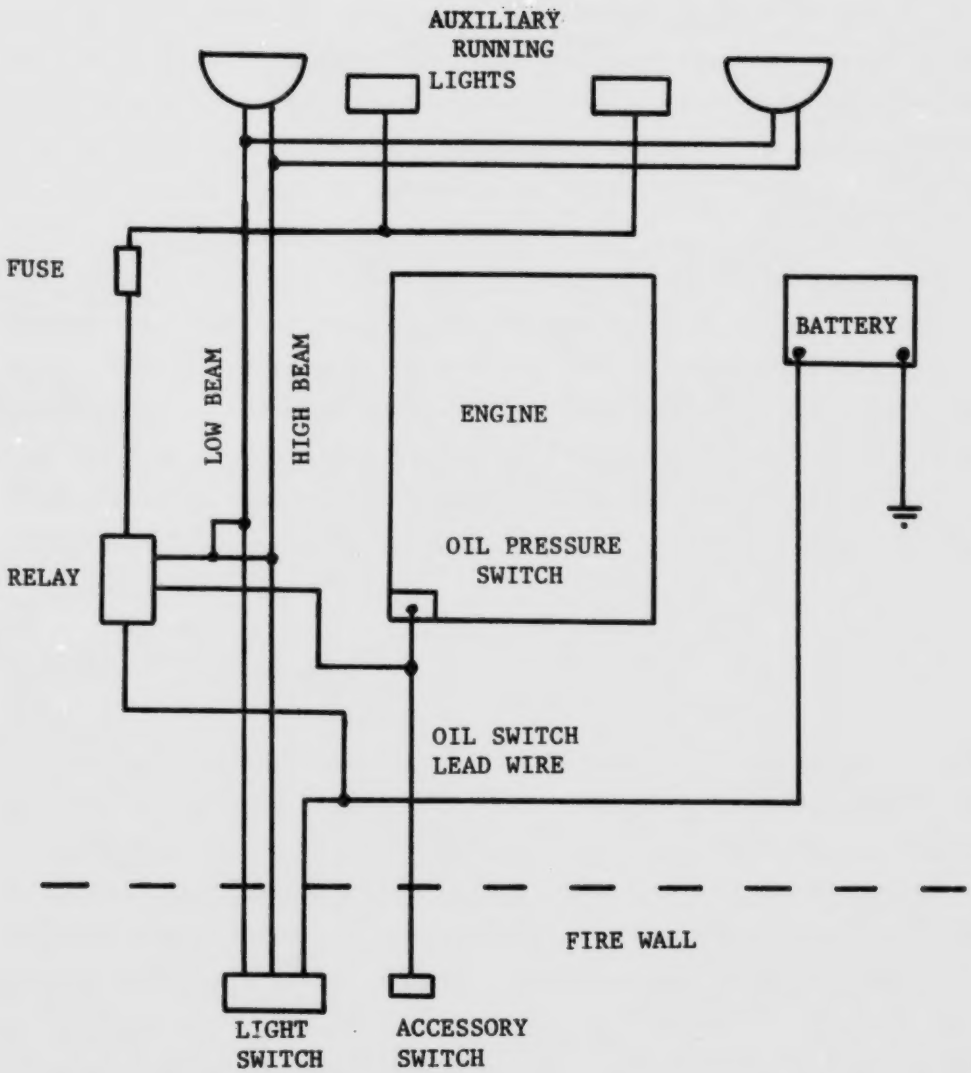


FIGURE 2.2: RETROFIT RUNNING LIGHTS WIRING DIAGRAM

2.4 INCREASED WATTAGE PARKING LIGHTS

This option is currently being used by the Insurance Institute for Highway Safety (IIHS). Their system consists of an interrupting switch triggered by the accessory circuit which automatically activates either all external lights or just the front parking lights. The standard front parking light bulb is replaced by a Westinghouse bulb developed especially for the task. This bulb increases the conventional parking light intensity to a 15 candle-power rating. It should be noted that all rewiring is done within the engine compartment and no access to the passenger compartment is required.

The circuit diagram for the system employed by IIHS is presented in Figure 2.3. The current cost of the system is US $15 (these are the costs which are currently incurred by Carlow and Associates, the contractor for the IIHS experiment). This cost converts to approximately $18 Canadian and does not include an installation cost. The current experience has shown that the average time for installation is approximately 15 minutes (at $20-30/hr). The total system cost would be $23-25 per installed unit.

2.5 CONSTANT-ON TURN SIGNALS

In this option, the turn signal wiring would be reconfigured so that the high intensity turn signal bulb usually found in vehicles would come on with the activation of the accessories circuit. However, to achieve this extremely complicated switching procedure, it requires a complete ignition tumbler rewiring to rearrange the contact sequences. This change would be a costly proposition due to the tumbler redesign.

Another problem has been identified with this system. With the turn bulb on constantly, there is increased heat build up within the light cavity. This heat build up has caused the plastic to warp on several vehicles tested by the IIHS in their preliminary investigation of system options.

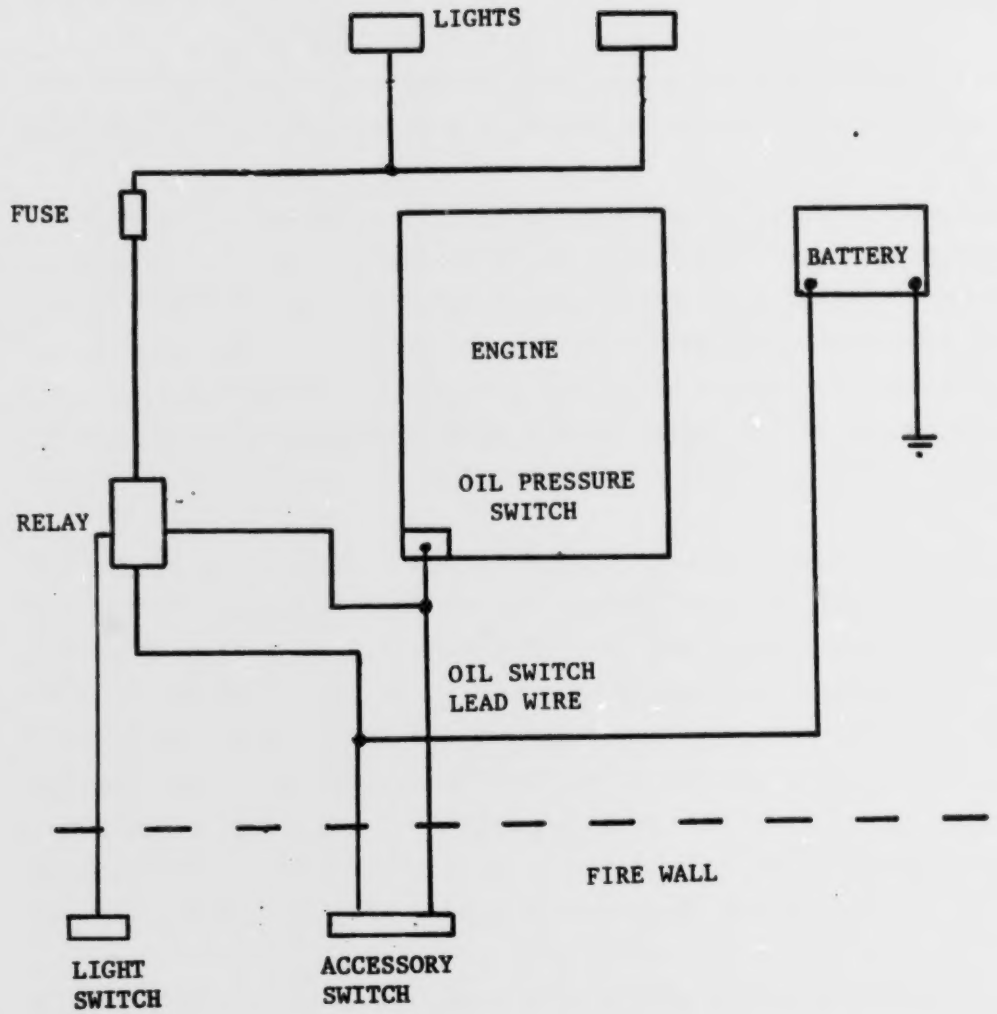


FIGURE 2.3: PARKING LIGHTS WIRING DIAGRAM

It was not possible to get an accurate cost for this option as it would require a new wiring harness to be fabricated along with an extensive amount of labour time to install it. This option, however, may be more suitable for large scale manufacturing if and when a regulation requiring lights on is implemented.

2.6 OPTION TRADE-OFF ANALYSIS

The qualitative and quantitative characteristics of the various options discussed previously have been presented in tabular form in Figure 2.4.

Based on this comparison, it is readily apparent that several options can be deleted from further consideration. The constant-on turn signal option is beyond the cost range supportable by this project. Further, the driving light option has the second highest cost and results in external modifications to the car. It should be expected that any external modifications would have low acceptance by the candidate vehicle owners and thus should not be considered.

The two remaining options are effectively tied as acceptable options. The cost structures of both the low voltage headlight and the high-power parking light options are essentially the same initial capital cost. However, the bulb replacement cost for the headlight system is significantly higher than the parking light (more than $15 compared to less than $1). In both cases, there is no external sign of vehicle modification apart from the lights being on. The most significant physical difference between these two systems is the lower uniformity of position, colour and size in the parking light option.

On the basis of this comparison, only the low voltage headlight and the high powered parking light options are considered for further investigation in this study.

FIGURE 2.4: DRL HARDWARE COMPARISON

OPTION	COST		UNIFORMITY OF POSITION/SIZE	COST OF LIGHT REPLACEMENT	EXTERNAL MODIFICATION	OTHER COMMENTS
	PARTS	LABOUR				
Low Voltage Headlights	$15	$5-8	Best	High (≈$15)	No	Normal headlight power demand at all times
Running Lights	$40	$15-25	Fair/Good	Low (≈$1)	Yes	No standard attachment position or method
High-power Parking Light	$18	$5-8	Poor	Low (≈$1)	No	Requires custom-made bulb
Constant-On Turn Signals	>$50	>$50	Poor	Low (≈$1)	No	Heat build-up requires major rewiring

2.7 HIGH-MOUNT BRAKE LIGHTS

The hardware required for the high-mount brake lights (HBL) is currently available in the U.S. and Canada. The U.S. equipment was originally developed as part of the DOT taxi fleet study (1) by Amerace Brands Inc. They are still the manufacturer of the equipment (see Appendix A) but the distribution is handled by Laser Corp. of California under the product name of 'HiLite'.

Another product is currently being marketed in Canada by Canadian Tire Corp. This system consists of two pedestal lights which mount inside the car on the rear shelf. They are much more difficult to install than the Amerace product and do not accomodate 'single-wire' light systems (designed for European cars with separate brake wires). As a result, the costing assumes the use of a product similar to the Amerace device.

The Amerace system is designed to operate on either a 'two-wire' light system (in which there is one wire for the turn light and one for stop lights) and a 'one-wire' system (in which all control is in one wire). The one-wire system requires a 'logic circuit' which will trigger the brake light only when the brake signal is sensed in the wire. This 'logic circuit' increases the cost of the one-wire systems compared to the two-wire systems.

There appears to be no advantage in attempting to redesign this product and very limited economic benefit to the development of a Canadian equivalent (if the regulations are enacted obviously there is a business opportunity for someone). The current wholesale prices for the single light units are U.S. $11.31 (Can. $13.57) and U.S. $15.52 (Can $18.62) for the dual and single wire systems, respectively. These prices might be lowered with bulk purchase discounts. Further, the addition of another light unit is not likely to double the cost and should produce a hardware cost of $20 and $30.

The installation time is approximately 15-20 minutes, or $5-10 at $20-30/hr. Thus, the total cost for the hardware and installation will be approximately $25-30 and $35-40 for the dual and single wire brake systems, respectively. For costing purposes, it is assumed that a 50/50 split of wiring systems would be encountered in the experimental fleet (most North American cars are single-wire systems) and thus an average installation cost of $30-35/unit is used in this study.

3.0 OPERATIONAL OPTIONS

3.1 HARDWARE INSTALLATION OPTIONS

The experimental equipment can be installed in two ways:

- production line installation on new cars;
- field installation by contracted garages.

With the production line option, there is not expected to be any cost saving on hardware costs. There could be some reduction in the labour costs due to reduced installation time (per hour labour rates will generally be higher than field installation option). Although several domestic manufacturers were contacted informally, no good quantitative estimates of the reduction in installation time were available.

Several other constraints with the production line installation option must be noted:

- the option would be restricted to a few model lines as it is unlikely that any one manufacturer could install the kits in a variety of assembly plants;

- it would be difficult to control where the reconfigured vehicle was finally operated and who it was insured by;

- because the customer would have to agree to participate after the vehicle had been produced, the manufacturer (dealers to a larger extent) would be reluctant to participate as it would, to some extent, restrict vehicle sales;

- as all vehicles would be new, there would be an exposure bias due to the non-random nature of the fleet;

- only domestic manufacturers would be involved, thus further biasing the total sample.

The alternate option of field installation overcomes virtually all the problems of production line installation. While the installation time may be marginally longer, aftermarket labour rates are lower (and perhaps more competitive) than manufacturing rates.

Further, the participants can be selected before installation and selected by insurance company affiliation. A fully representative sample of all sizes and ages of vehicles as well as the location of the participant can be assured.

Thus, it appears that field installation is a much more attractive option as sampling validity can be assured with minimal cost penalty. For these reasons production line installation is not recommended for the field trial and is not considered in this costing exercise.

3.2 SOURCES FOR FIELD TRIAL PARTICIPANTS

In order to develop the sample sizes outlined in the next chapter, participants will have to be selected in such a way as to represent general vehicle population. It should be noted that this study assumes that a representative sample is required. The alternative of a biased sample (i.e., one in which high vehicle utilization or accident rates occur) is therefore only acceptable if the exposure/accident characteristics are similar to the general vehicle data. In order to develop a contact list of potential project participants, mailing or contact lists can be created in the following ways:

- through a sample drawn from the motor vehicle registration list or driver registration list of each province;

- through a sample of insurance company policy holders;
- through direct solicitation at employment nodes such as major employers within a region;
- through use of fleet vehicles (e.g., Bell Canada, rental cars, etc.)

Each one of these will be briefly discussed below.

3.2.1 Registration Lists

A sample of registration information could be drawn from provincial records. However, this procedure is somewhat difficult to arrange due to the confidentiality of the registration information and the problems of getting sampling done by the registrars. The method, however, has been used for the current quarterly fuel economy survey undertaken by Statistics Canada and it is possible this same database could be accessed to draw the initial sample for this experiment. Another consideration against this option is the non-specific association of the drawn sample to any one insurance company. This would greatly increase the complexity and cost of obtaining accident records (see Section 3.3).

3.2.2 Insurance Company Files

If, as discussed in Section 3.3., the most appropriate way of tracking the accident history of the participant vehicles is through insurance records, then an appropriate way of selecting the initial sample would be through those same companies. From initial discussions with the insurance companies this option is feasible, although adequate assurance of confidentiality and cost recovery for the insurance companies participation would have to be arranged. Listings of their policy holders (name, address, vehicle type, etc.) are typically on computer tape and, therefore, a random sample of these tapes could produce a mailing list for initial sample selection. (Note that in four

provinces - B.C., Saskatchewan, Manitoba and Quebec - the insurance is provincially-run and all vehicle records are centralized.) The use of this approach could also stimulate higher participation rates if the insurance companies were to use their letterhead and/or local agents for contacting potential experiment participants.

3.2.3 Major Employers

Another route to identifying and approaching random participants for this experiment would be through major regional employers. This process would have the benefit of operationally simplifying the solicitation of participation. In each case, the employer would have to be convinced of the "worth" of the project and lend his moral persuasion to the project. Because of the concentration of the experimental sample group, the organization of the equipment installation could be easier than in other options.

However, it would also be a condition that the employer use a group insurance plan such that the accident records could be traceable through one, or at most two insurance firms for cost-effective accident tracking. In the case of B.C., Saskatchewan and Manitoba, which have provincial insurance plans, these vehicle records are accessible and thus this option is attractive. For the remaining provinces this requirement for common insurers will significantly decrease the number of applicable employers thus making this option unattractive.

3.2.4 Major Fleet Operators

The obvious alternative to selecting privately-owned vehicles is the use of commercial vehicles operating in fleets. This approach has been taken in the U.S. studies of DRL and HBL. (1,5,6). The principal drawback of this option is the biasing in driver, vehicle and exposure characteristics which make the test potentially non-representative of the general vehicle population (e.g., the Essex taxi study was biased towards large vehicles and high accident rate vehicles).

If fleets are to be used, then several criteria must be satisfied for their inclusion in the experimental fleet:

- for DRL, vehicle usage must be primarily in daytime and representative of general exposure characteristics;
- accident records must be complete, either through the fleet management system or through the fleet insurance files;
- annual exposure (km/yr) or accident rates must be higher than the general population (or else there is no economic reason for using a biased sample).

The major cost advantage of this option would be in the reduction of the number of participating organizations or individuals (i.e., an intermediate level organizer) placed between the contractor and the target vehicle. While there are a number of large fleets which could be used for this option (e.g., municipalities, utilities, oil companies, etc.) many of these have below average annual vehicle usage (e.g., Bell Canada and most municipalities) which makes them unattractive. Furthermore, many of the commercial fleets have lower than average accident rates which would either decrease the statistical reliability of the results or require a proportionally larger fleet.

Finally, the number of vehicles in large fleets is limited to perhaps 10-15,000 in all of Canada (note this is only an estimate as there are no accurate statistics). It should also be noted that the vehicles of large fleets are geographically dispersed making each "site" fleet size smaller. A much larger pool of vehicles is in smaller fleets of 5-100 (perhaps upwards of 40-60,000). Thus, once the number of test vehicles exceeds a few thousand the average fleet size will decrease significantly. For the purposes of the costing later in this report an average fleet size of 50 vehicles was assumed.

3.3 DATA TRACKING

In the design of this experiment, one of the most important factors is the accurate compilation and subsequent analysis of the accident data. The criteria for the design of the data tracking system were identified as the following items:

- the accident record must be specific to the individual vehicle;
- the accident must be described in detail as to where, when, why, who, and how it occurred;
- there must be accurate cost information concerning the accident;
- the records should be in relatively centralized locations to decrease the access costs;
- if possible, the information should be electronically encoded to facilitate sorting and transfer of information.

Based on the assumption that the experimental fleet is a random sample of vehicles in operation, then there are only two major sources for accident data available. These are:

a) the police accident reports, and

b) the insurance accident records.

If a non-random fleet was used for the experiment then it may be possible to obtain the accident information through fleet maintenance records such as those maintained by Bell Canada, Imperial Oil or any other major fleet of vehicles.

Each of these three possible sources of data will be discussed briefly below.

3.3.1 Police Accident Records

At the site of every reportable accident (generally involving property damage greater than $200), a police record is completed in a relatively standard manner across Canada. This information is then transcribed into a computer database after some processing delay. The information contained in this database is of sufficient detail and, in general, quality to be useful in this study. However, the one variable which has historically proven to be unreliable is the estimated cost of the accident. Further, the classification of accidents used in the database may not be suitable to that required for this experiment. Thus, the police records, although useful, may not provide the exact information base required for the experiment.

3.3.2 Insurance Company Records

Each insurance company maintains a complete set of accident records for its policy holders. These records contain accurate information concerning the policy holder, the insured vehicle and records describing each accident.

For private insurance companies, the files contain full information on all first party claims (where the insured was at fault) and more limited data on third party claims (insured not at fault). There are some cases where the third party claims are not identified (i.e., the insurance company was not informed) and thus those accidents would be lost. According to insurance company representatives, these losses are a small percentage of the total accident file. To further reduce this loss, participants could be specifically instructed to report any accidents to their agent thus decreasing the losses.

For provincially-run insurance schemes, there is no tracking problem because all the vehicles are under one insurer and third party files are cross-linked to first party claims. Thus, any vehicle's total accident history can be created through file querying.

Each first party accident file contains the police accident report plus any vehicle repair or medical expenses which were incurred in the accident. Thus, this data source is a more robust file than the police records. The one major drawback concerning this source of information is that the detailed information is not computerized. However, the summary information (i.e., that a certain vehicle was in an accident) is usually computerized, and initial file sorting can be undertaken efficiently.

In discussions with the major Canadian insurance companies during this project, it was determined that, given proper controls on the accessibility and use of the data and waivers from the policy holders, the insurance companies would become involved in such an experiment. The most likely condition associated with their involvement would be a cost recovery of the time and expenses in extraction of the accident records on behalf of the contractor undertaking the experiment. It was confirmed that, given a list of target vehicles, the insurance company could draw out the accident files over a set time period for each vehicle and provide the contractor with a facsimile of the file information. The contractor would then undertake the coding of the appropriate information from the file. In this way, a consistent coding system would be assured throughout the experiment.

From past experience in undertaking this type of data tracking (3), this process provides an accurate and consistent database at a relatively low cost. Because the information is obtained from the insurance company without any modification of their data and at relatively low cost and low disruption factor for their operation, the companies tend to be amenable to providing this type of information.

For the above reasons, this option is identified as the preferred source of accident data for a general vehicle experiment. For all subsequent cost estimates of a general vehicle sample, it is assumed that insurance company data will be the source of the accident data for the general population fleet.

3.3.3 Fleet Records

In most well operated fleets, accident reports are prepared after each accident (usually no minimum damage levels are required). These reports are created for internal corporate goals and can be quite varied in accident detail and accuracy. However, these records can be used as exemplified by the Essex (5), Allen (1) and IIHS (6) studies on HBL and DRL. In both these cases, arrangements were made with the participating fleet operators for the accident reports to be sent directly to the contractor for coding and key-punching. The fleets were pre-screened to ensure that their accident report forms provided sufficient data.

The cost of creating the accident record database from fleet records is expected to be approximately the same as the insurance file option. The accuracy can be equal to the insurance files, but in smaller fleets the accident data may not be as complete.

3.4 DURATION OF TRIAL

One of the major experimental design variables is the length of the field trial. Because the sample size is dependent upon the total number of expected accidents, the trial period can be longer and the required sample size can be smaller for the same level of statistical accuracy. The decrease in sample size is not, however, directly proportional to the increase in trial time as there will be participant drop-out. Participant drop-out is due to a number of factors:

- de-commissioning of the vehicle (due to age or damage);

- change of ownership (it is improbable that the new owner would be with the same insurance company except in B.C., Saskatchewan, Manitoba and Quebec);

- change of address of participant (to outside of the test area);

- participant withdraws from program (e.g., remove device).

The magnitude of these factors will be different depending on whether the vehicle is privately or fleet operated.

While it is difficult to accurately estimate the final drop-out rate per year the following approximations are made:

FACTOR	PRIVATE	FLEET
vehicle de-commissioning	1%	1%
change of ownership	15-20%	20-33%
change of address	5-10%	--
participant withdrawal	1-5%	1-5%
total annual drop-out	22-36%	22-39%

These estimates are based on a fully representative sample of the stock of vehicles, thus the values represent the average probability of any one chosen vehicle not surviving the year. By biasing the selection process to select only those vehicles which are expected to be held by the operator for the duration of the trial, the change of ownership factor can be substantially decreased. However, this will tend to bias the test fleet to younger vehicles. The commercial fleet option has a higher change of ownership rate (3-5 year service life) and, presuming a maximum of a 2-year program, up to 2/3 of the fleet could be disqualified at the outset of the program.

In discussions with both IIHS and Allen Corp. personnel, they strongly recommended that the duration of the trial be minimized because of the drop-outs and participant tracking problems. They have found tracking costs to be high especially where co-operation from the operator on accident data is required.

Further, the drop-outs will probably be non-random and can be expected to be higher for more mobile or higher income (due to more frequent vehicle replacement) participants. This effect could seriously bias the experimental sample and cause an underestimation of the device's effectiveness.

For these reasons, the shortest test period should be chosen even if there is a slight cost penalty. For the purposes of study design and costing, a one year trial was selected for sample sizing. A two year option was also costed using an assumption of a 50% decrease in the sample size.

3.5 GEOGRAPHIC DISTRIBUTION

The intent of this field trial is to provide a representative test of the experimental systems throughout Canada. Therefore, it will be required to have the vehicles distributed in all major regions of Canada. The vehicles should not be abnormally concentrated in the major cities, but be proportionally distributed within each region by urban size.

For the purpose of study design, five geographic regions were identified. These were:

- Maritimes
- Quebec
- Southern Ontario
- the Prairies
- Southwest B.C.

Within each of these regions, the vehicles should be proportionally distributed in cities and towns down to approximately 10,000 population.

For operational efficiency, the smallest fleet size (experimental) in any one centre should be approximately 100 vehicles (1% of sample). At this level, there should be a minimum 'copycat' effect on the rest of the local population. Furthermore, this fleet size would approximate one person-week for installation.

4.0 SAMPLE SIZE ANALYSIS

As the decisions resting on the results of the potential test of daytime running lights and high-mounted brake lights could result in the adoption of vehicle standards which would increase the cost of manufacturing automobiles, it is assumed that there is some minimum economic break-even point for accident reduction which is required from this experiment. The ideal sample size for this experiment is the smallest that can detect this required minimum reduction with an acceptable level of statistical error. Further, because the capital costs of modifying vehicles for the experiment are significant, it is important to make design choices which minimize sample size.

A discussion of the major areas of design choice follows. Much of this discussion centres around the different combinations of Type I and Type II error probabilities which are acceptable and the conditions attached to their acceptability. The calculated sample size requirements based on these errors and likely levels of accident reduction are shown in Tables 4.1 and 4.2.

4.1 ACCIDENT REDUCTION RATES

The starting point for any sample size analysis in road safety is an estimate of the likely reduction in relevant accidents which will result from application of the measure. From the calculations of Transport Canada and previous studies (3), it was estimated that 23% of all accidents are relevant to DRL and 30% are relevant to HBL. As the overall rate of accident involvement is close to ten percent of the private vehicle fleet per year (4), the applicable involvement rate which may be influenced by these systems is estimated to be 0.023 and 0.03, for DRL and HBL respectively.

The measured reduction in the incidence of accidents is unquestionably the most concrete justification for additional safety equipment, but it is a conservative approach compared to other more controversial criteria which might be measured using smaller samples. For example, reduction in vehicle repair costs is a potentially attractive alternative criterion. This is primarily due to the fact that DRL/HBL may also help reduce the severity of damage of applicable accidents which do occur, and this effect is not captured by accident rate. However, the inconsistency with which costs are recorded presents difficulties both for the calculation of sample size and for the eventual tracking of the experimental results. For this reason, the use of damage repair costs and other alternative prime evaluation criteria were not pursued, and the calculation of sample size was based solely on the reduction of relevant accidents.

Several levels of accident reduction for the two experimental systems, selected for the examples shown in Tables 4.1 and 4.2 were based partially on the range of effects in the previous related studies. As these expected levels of reduction have an enormous effect on sample size, the minimum level it is desired to detect should not be arbitrary. Rather, an explicit decision rule should be adopted, such as a crude cost/benefit ratio (e.g., the average costs of an accident should be compared to the cost of the system as it would be produced and operated, divided by the number of years of expected service). Note that if the trial is set up to detect the **SMALLEST** accident reduction which would justify the equipment, the trial may have to be quite large.

To the extent that DRL/HBL systems are relatively inexpensive and average accident costs are high, the minimum accident reduction to justify a standard will be small, and the sample size needed to prove it will be large. Conversely, if the trial is set up to detect an accident reduction substantially greater than that needed to "break even", then the required sample size could be significantly reduced.

FIGURE 4.1: DRL SAMPLE SIZE REQUIREMENTS[1,2]

PROBABILITY OF ERROR		EXPECTED ACCIDENT REDUCTION[3]			
Type I	Type II	10%	15%	20%	25%
0.05	0.10	70,100[4]	26,700	16,900	10,400
	0.30	38,900	16,600	9,450	5,850
	0.50	22,800	9,750	5,610	3,510
0.10	0.10	54,000	22,900	13,100	8,040
	0.30	27,300	11,700	6,680	4,160
	0.50	14,200	6,140	3,570	2,260
0.20	0.30	16,700	7,020	4,000	2,470
	0.50	6,330	2,670	1,520	940

1. Based on a 12 month experiment with global accident rate of 0.1 accidents per vehicle per year.
2. Sample sizes shown are for either experimental or control group. Twice these numbers would be tracked on accident experience, but hardware modification would be undertaken for fleets of the above sizes.
3. Reduction in applicable accidents (23% of all accidents).
4. Variance (V) is assumed to be P(1-P)=.0225 where P=0.023.

Sample size formula:

$$N = 2\,\frac{(Z_{(1-a)} - Z_{(b)})^2}{d^2}$$

where $d = 2\sqrt{\frac{W^2}{1-W^2}}$, $\frac{W^2 = (P - P_2)^2}{4V_y 2}$ and Z = normal propability function

FIGURE 4.2: HBL SAMPLE SIZE REQUIREMENTS[1,2] (in 000's)

PROBABILITY OF ERROR		EXPECTED ACCIDENT REDUCTION[3]		
Type I	Type II	10%	30%	50%
0.05	0.10	53,400[4]	5,480	1,810
	0.30	29,600	3,110	1,050
	0.50	17,300	1,880	660
0.10	0.10	41,200	4,250	1,420
	0.30	20,800	2,220	770
	0.50	10,800	1,220	450
0.20	0.30	12,110	1,340	490
	0.50	4,600	510	190

1. Based on a 12 month experiment with global accident rate of 0.1 accidents per vehicle per year.
2. Sample sizes shown are for either experimental or control group. Twice these numbers would be tracked on accident experience, but hardware modification would be undertaken for fleets of the above sizes.
3. Reduction in applicable accidents (30% of all accidents).
4. Variance (V) is assumed to be P(1-P)=.0291 where P=.03.

Sample size formula:

$$N = 2\,\frac{(Z_{(1-a)} - Z_{(b)})^2}{d^2}$$

where $d = 2\sqrt{\frac{W^2}{1-W^2}}$, $W^2 = \frac{(P_1 - P_2)^2}{4V_{y2}}$ and Z = normal probability function

4.2 LEVEL OF STATISTICAL SIGNIFICANCE

In this experiment, it is expected that the mean accident rate for the experimental and control groups will be compared. In conventional statistical terms, there would be two hypotheses:

- the difference between the means is less than that needed to justify a DRL/HBL standard (the "Null" hypothesis);

- the difference between the means is equal to or greater than the minimum needed to justify the standard (the "Experimental" hypothesis).

It has become a convention in road safety projects to require Type I (alpha) error probability no greater than five or ten percent and to allow Type II (beta) error probability to be as high as 50% (i.e., to accept tests low on statistical power). To apply such significance levels to the above hypotheses would imply that the error of adopting the standard when the trial demonstrated a **spuriously** sufficient accident reduction is more serious than the error of rejecting the standard when the trial **falsely** suggested that the minimum desired accident reduction was not attained.

To set the acceptable levels of significance, it is necessary to evaluate the risks involved with both types of error. It might be argued, for example, that enough other research has shown accident reductions after installing DRL/HBL. Thus, it is better to risk a small unjustified increase in automobile production costs than to risk an unjustified rejection of an opportunity to reduce accidents (in which case it would be logical to reverse the order of the above hypotheses).

Tables 4.1 and 4.2 show what sample size is required to allow results to be determined with differing combinations of Type I and Type II error probabilities. The choice of error probabilities is largely subjective; it relates ultimately to how rigorously the credibility of a negative or positive evaluation of DRL/HBL must be defended on statistical grounds. In the Tables, the highest error probabilities shown (0.2 for Type I and 0.5 for Type II) are almost certainly too high to be used in support of a national outcome; they are included to illustrate the possibility of being able to make statements from regional subsamples with marginal statistical significance.

4.3 REQUIREMENT FOR SUB-SAMPLE RESULTS

In the discussions with Transport Canada concerning the planning of this experiment, concerns were expressed about the capability to show the effectiveness of the system by location (latitude), time of year, vehicle class, vehicle age, weather or light conditions, and driver culpability. While data on all of these factors should be collected in the trial, only the locational subgroups were considered to warrant efforts to guarantee minimum sub-sample sizes. It was thus hoped to ensure that statistically significant results could be reported by region. However, regional effectiveness was perceived to be much more of an issue for DRL than for HBL.

As discussed in Section 3.5, it was assumed that region would be defined to be five familiar groupings of provinces within the national sample. For each region to be able to show DRL effectivenesss at the same level of statistical confidence as outlined in the previous section, the sample sizes would have to be as shown in Table 4.1. Multiplying these numbers by five suggests that this would be financially infeasible. Therefore, unless DRL effectiveness was much higher than anticipated, it would seem prudent to accept less statistical rigour at the regional level. Thus, higher Type I and Type II error probabilities would be incurred. The results, however, can be analyzed to indicate that the direction of

changes are consistent with the national result and, within the statistical bounds possible, that the magnitude of the results are similar.

These considerations of minimum regional sub-sample size also interact with another operational design issue - the distribution of the sample across Canada.

4.4 STRATIFICATION OF THE SAMPLE

The primary analytical requirement of the DRL/HBL experiments is the estimation of a national mean effect of the equipment on accident rate. While vehicles should, theoretically, be randomly sampled throughout Canada, operational constraints require that available test localities centred on an installation facility first be selected as Primary Sampling Units (PSU's, as discussed in Section 3). Moreover, the number of vehicles in the test localities should neither be too small (installation facility limitations), nor too large (too many modified vehicles in one locality might lead to imitation and "halo" effects).

There are a number of approaches to maximizing the representativeness of PSU selection under these constraints. It is recommended that the following two-stage approach be used:

1. Stratify by region: in order to be able to report at least directionally meaningful results by region, the chosen sample size should be equally distributed across the five groupings of provinces. This will require that weighting be used in the estimation of national results because there is more than a fourfold difference in the number of vehicles in the least populated versus the most populated region.

2. Within regions, simple probability selection should be used for PSU's based on the size of the vehicle fleet in PSU's vulnerable to selection. In the case of the general

population option, this may involve establishing the maximum distance which a vehicle would be expected to travel in order to undergo a DRL or HBL retrofit and estimating how many vehicles associated with the source of respondents (e.g., an insurance company) are typically found within that radius. In the case of the commercial fleet option, the fleet sizes served by maintenance centres are presumably known.

More elaborate stratification of the sample is not justified given the unavoidable element of voluntary participation in the general population option and the inherent biases of commercial fleets should they be used.

4.5 CONTROL GROUP

In the sample size analysis, it was assumed that the experiments would use control groups of the same size as the experimental groups. This section discusses the rationale for that assumption. Two possibilities exist for a comparison group:

a) use the overall accident statistical database for all automobiles;

b) use a control group selected from the same source as the experimental group using random assignment.

The use of (a) implies comparing the relevant accident rates of the experimental vehicles to the "background" rate for all vehicles in the same data collection area. Such an alternative is not satisfactory for several reasons:

- the size of the effects we are trying to detect are extremely small -- about a ten percent change in an annual rate of 0.023 in the worst case;

- for practical purposes, the experiment is limited to certain sources of subject vehicles rather than a truly random sample drawn from all vehicles in Canada;

- the standard of credibility needed in a study which possibly leads to manufacturing standards is high.

Thus, random assignment of control and experimental groups from the same sources is essential. Given this approach there is, of course, no reason to make the control groups larger than the experimental groups.

5.0 FIELD TRIAL COSTING

5.1 TASK BREAKDOWN

For both DRL and HBL systems, similar task breakdowns were formulated. The implementation approaches were grouped into two major options:

- general population fleet,
- commercial fleet (for costing purposes an average fleet size per site of 50 vehicles was assumed).

Within each option, six major task areas were identified:

1. Trial Set-up
2. Sample Selection
3. Hardware Installation
4. Data Acquisition
5. Trial Analysis
6. Project Management.

Sub-tasks were identified within each major task. The following text briefly describes each sub-task and the costing assumptions made are noted in parentheses. (Person-day estimates, expense costs, and average per diem fee). The private and commercial options have the same assumptions unless specifically noted. The costs are for a one year trial. Two year trial costs are discussed in Section 5.2 and 5.3.

The task breakdown and costing relationships were constructed into a computer 'spread-sheet' model (Supercalc). Examples of the output of this model are provided in Figures 5.1 and 5.2 for the DRL and HBL cost structures respectively. A full program listing is provided in Appendix C.

5.1.1 Trial Set-Up

This task accommodates the 'front-end' requirements of negotiating arrangements with insurance companies, registration agencies, fleets and equipment installers. The sub-tasks are:

1.1 Sample Access - approach, select and negotiate access to files of potential participants from registrars, insurance companies, etc. (5 days + 5 days per 10,000 vehicles in total sample: per diem cost $375)

1.2 Records Access - negotiate the access to accident records for the sample set of 1.1 through police records or insurance companies. (5 days + 1 day per 10,000 vehicles in total sample: per diem cost of $375)

1.3 Installation Contract - arrange for the acquisition of retrofit equipment and contract for installation of equipment in test regions. (10 days + 5 days per 10,000 vehicles in total sample: per diem cost $375)

In all these tasks, the capital costs represent travel and expense costs.

5.1.2 Sample Selection

This task includes the construction of a list of possible participants from the insurance (or registration) files and the selection and acceptance of the participant vehicles. It is assumed that twice the final fleet size is used to size the contact list.

2.1 File Forming - this covers the compilation of a mailing (contact) list of vehicles (fleets) from insurance or registration files (list is twice the final sample requirement), and includes processing and programming costs. (5 days per region (5): $0.10/name for private vehicles or $0.20 for fleet: per diem cost $300)

2.2 Initial Screening - based on the drawn sample (twice final sample size), initial contact will be made by mail to solicit participation in the trial. Costs involved are labour, mailing and processing costs. (20 days + 1 day per 5,000 private vehicles or 20 days + 1 day per 20 fleets: $1.50/ mailing: per diem cost $300)

2.3 Control Acceptance - the responding sample (half of mailing) from 2.2 will be split in half (control/experimental). The control group will be requested to allow access to accident records. (5 days for private vehicles or 1 day per 10 fleets: $1.00/acceptance: per diem cost $300)

2.4 Experimental Acceptance - similar to 2.3 but initial scheduling of vehicle retrofitting will be planning, and informing participants of retrofit locations. (10 days for private vehicles or 1 day per 2 fleets: $1.00/acceptance: per diem cost $300)

5.1.3 Hardware Installation

This task covers the labour, capital and management costs of installing, repairing and removing the test equipment. The sub-tasks are:

3.1 Contractor Co-ordination - covers the management of the installation contractors and travel associated with task. (2 days per 1,000 vehicles for private vehicles or ½ day per fleet: travel costs of $5,000: per diem cost $500)

3.2 Appointment Management - it is assumed that at each installation centre a supervisor will be responsible for scheduling the individual vehicles for retrofitting. (5 minutes per experimental vehicle: per diem cost $100)

3.3 Installation - the costs for this task are based on expected installation times, labour rates and equipment unit costs. (Installation time as defined: hardware cost as defined: per diem cost 7.5 x mechanic $/hr);

3.4 Equipment Repairs - it is anticipated that there will be equipment failures during the trial. This task budgets that 10% of the units fail and need repair. (10% of installation time and hardware cost: per diem cost 7.5 x mechanics $/hr.: for 2 year program a further 5% repair frequency is assumed).

3.5 Equipment Removal - at the end of the trial, the participants will be given a choice of keeping the equipment or having it removed. An assumption of a 100% removal rate is made for costing purposes. (Removal time as defined: no value for scrap: per diem cost 7.5 x mechanic $/hr.)

5.1.4 Data Acquisition

This task entails the tracking of participation, data collection, coding and editing. The sub-tasks are:

4.1 Participation Survey (for both cells) - in order to obtain feedback from both experimental groups on their participation in the experiment, and perceptions of the equipment's usefulness, and some measure of intermediate accident rates one participant survey (questionnaire) is proposed at the end of the one year trial. Two surveys are assumed with a two year option. The costs are primarily for mailing and processing. (10 days + 1 day per 500 participants per survey: $2.50 per questionnaire: per diem costs $300)

4.2 Forms Retrieval - at intervals throughout the experimental period (or at the end) the insurance companies will select the records of those participant vehicles (both cells) which were involved in reported accidents. It is assumed that automated sorting can be used and thus the costs are for file access and copying only. (15 minutes per accident record (10%): copy costs of $0.20 per record: per diem costs $200)

4.3 Data Coding - to obtain consistency in coding, the raw accident forms will be coded by contractor staff. Based on previous studies, an estimate of 15 minutes per file was assumed. (15 minutes per accident record: no expenses: per diem cost $150)

4.4 Data Entry - the coded data will be put into machine-readable form in this sub-task. (1 day of management time: $0.20 per record for keypunching: per diem cost $375)

4.5 Data Editing - the data file will be edited through the application of a series of logic checks. (3 days: $0.02 computer costs per record: per diem cost $375)

5.1.5 Field Trial Analysis

The costing assumes that a statistical and economic analysis of the field trial results is required along with a final report.

5.1 Statistical Analysis - the data file will be analyzed using normal statistical methods. (10 days which is insensitive to fleet size: $1,000 in computer and miscellaneous costs: per diem cost of $500)

5.2 Economic Analysis - the results of the statistical analysis and the cost information will be incorporated into a preliminary economic impact assessment for use in regulation justification. (10 days: $500 in costs: per diem costs $500)

5.3 Report Preparation - this task covers documentation, graphics and printing costs of a final report to Transport Canada standards. (10 days: $500 in costs: per diem cost $500).

5.1.6 Project Management

This task covers a miscellaneous capital budget (for travel and contingency) as well as labour costs for the project manager. (25 days + 2 days per 1,000 vehicles in sample for private vehicles or 25 days + ½ day per fleet (50 vehicles): $2,000 + $1,000 per 5,000 private vehicles or $7,500 + $1,000/5,000 fleet vehicles: per diem cost $600). For the two year option these costs are doubled.

FIGURE 5.1: EXAMPLE OF DRL COST ESTIMATE

DRL FIELD TRIAL COSTING PROGRAM
REDUCED VOLTAGE HEADLIGHTS OR PARKING LIGHTS OPTION (1 year trial)

DESIGN VARIABLES

INITIAL SAMPLE SIZE:		COST ITEMS:	
CONTROL GRP=	30000	HARDWARE ($/unit)	15.00
EXPER GRP =	30000	INSTALL TIME (min)	15
TOTAL =	60000	REMOVE TIME (min)	5
		MECHANIC RATE ($/hr)	30.00

TASKS	GENERAL POPULATION OPTION				COMMERCIAL FLEET OPTION				LABOUR $
	P-DAYS	LAB $	CAP $	TOT $	P-DAYS	LAB $	CAP $	TOT $	$/P-DAY
1. TRIAL SET-UP									
1.1 sample access	35	13125	2000	15125	35	13125	2000	15125	375
1.2 records access	11	4125	2000	6125	11	4125	2000	6125	375
1.3 installation	40	15000	4000	19000	40	15000	4000	19000	375
2. SAMPLE SELECTION									
2.1 file forming	25	7500	12000	19500	25	7500	480	7980	300
2.2 initial screening	44	13200	180000	193200	140	42000	3600	45600	300
2.3 control acceptance	5	1500	30000	31500	60	18000	600	18600	300
2.4 exper acceptance	10	3000	30000	33000	300	90000	600	90600	300
3. HARDWARE INSTALLATION									
3.1 contractor coord	60	30000	5000	35000	150	75000	5000	80000	500
3.2 appointment mgmt	333	33333	0	33333	333	33333	0	33333	100
3.3 installation	1000	225000	450000	675000	1000	225000	450000	675000	225
3.4 repairs	100	22500	45000	67500	100	22500	45000	67500	225
3.5 removal	333	75000	0	75000	333	75000	0	75000	225
4. DATA ACQUISITION									
4.1 participation survey	130	39000	150000	189000	130	39000	150000	189000	300
4.2 forms retrieval	200	40000	1200	41200	200	40000	1200	41200	200
4.3 coding	200	30000	0	30000	200	30000	0	30000	150
4.4 data entry	1	375	1200	1575	1	375	1200	1575	375
4.5 data editing	4	1575	120	1695	4	1575	120	1695	375
5. TRIAL ANALYSIS									
5.1 statistical analysis	10	5000	1000	6000	10	5000	1000	6000	500
5.2 economic analysis	10	5000	500	5500	10	5000	500	5500	500
5.3 report preparation	10	5000	500	5500	10	5000	500	5500	500
6. PROJECT MANAGEMENT	145	87000	14000	101000	325	195000	19500	214500	600
TOTALS	2707	656283	928520	1584753	3418	941533	687300	1628833	

FIGURE 5.2: EXAMPLE OF HBL COST ESTIMATE

HBL FIELD TRIAL COSTING PROGRAM
DUAL HIGH-MOUNTED BRAKE LIGHTS (1 year trial)

DESIGN VARIABLES

INITIAL SAMPLE SIZE:		COST ITEMS:	
CONTROL GRP=	5000	HARDWARE ($/unit)	30.00
EXPER GRP =	5000	INSTALL TIME (min)	15
TOTAL =	10000	REMOVE TIME (min)	15
		MECHANIC RATE ($/hr)	30.00

TASKS	GENERAL POPULATION OPTION				COMMERCIAL FLEET OPTION				LABOUR $
	P-DAYS	LAB $	CAP $	TOT $	P-DAYS	LAB $	CAP $	TOT $	$/P-DAY
1. TRIAL SET-UP									
1.1 sample access	10	3750	2000	5750	10	3750	2000	5750	375
1.2 records access	6	2250	2000	4250	6	2250	2000	4250	375
1.3 installation	15	5625	4000	9625	15	5625	4000	9625	375
2. SAMPLE SELECTION									
2.1 file forming	25	7500	2000	9500	25	7500	40	7540	300
2.2 initial screening	24	7200	30000	37200	40	12000	600	12600	300
2.3 control acceptance	5	1500	5000	6500	10	3000	100	3100	300
2.4 exper acceptance	10	3000	5000	8000	50	15000	100	15100	300
3. HARDWARE INSTALLATION									
3.1 contractor coord	10	5000	5000	10000	25	12500	5000	17500	500
3.2 appointment mgnt	56	5556	0	5556	56	5556	0	5556	100
3.3 installation	167	37500	150000	187500	167	37500	150000	187500	225
3.4 repairs	17	3750	15000	18750	17	3750	15000	18750	225
3.5 removal	167	37500	0	37500	167	37500	0	37500	225
4. DATA ACQUISITION									
4.1 participation survey	30	9000	25000	34000	30	9000	25000	34000	300
4.2 forms retrieval	33	6667	200	6867	33	6667	200	6867	200
4.3 coding	33	5000	0	5000	33	5000	0	5000	150
4.4 data entry	1	375	200	575	1	375	200	575	375
4.5 data editing	3	1200	20	1220	3	1200	20	1220	375
5. TRIAL ANALYSIS									
5.1 statistical analysis	10	5000	1000	6000	10	5000	1000	6000	500
5.2 economic analysis	10	5000	500	5500	10	5000	500	5500	500
5.3 report preparation	10	5000	500	5500	10	5000	500	5500	500
6. PROJECT MANAGEMENT	45	27000	4000	31000	75	45000	9500	54500	600
TOTALS	686	184372	251420	435792	792	228172	215760	443932	

5.2 DRL COSTING

Using the estimates of equipment costs and installation times (for simplicity the headlight and parking light options were merged) outlined in Chapter 2 and the sample size ranges scoped in Chapter 4, a series of cost estimates were produced.

The costing assumptions were:

Factor	Low Cost	High Cost
DRL		
Hardware Cost ($/unit)	15.00	20.00
Installation Time (min.)	15	30
Removal Time (min.)	5	15
Mechanic Rate ($/hr.)	20.00	30.00
Drop-out Rate/yr.	22	36
HBL		
Hardware Cost ($/unit)	30.00	35.00
Installation Time (min.)	15	30
Removal Time (min.)	15	30
Mechanic Rate ($/hr.)	20.00	30.00
Drop-out Rate/yr.	22	39

The estimates within these ranges are plotted in Figure 5.3. It should be noted that the sample sizes developed in Chapter 4 are the sample sizes at the end of the trial. These values must be inflated by the expected dropout rate to arrive at the total initial sample size and program costs.

Based on the cost model, estimated drop-out rates and the sample sizes of Figure 4.1, a composite table of program costs by level of statistical accuracy and accident reduction rates was developed (see Figure 5.4, 5.5 and Appendix B). These costs were developed based on a private fleet option for the two year program (there is very little difference in the costs between private and fleet options).

It should be cautioned that although a fleet option was costed throughout the range of sample sizes , it would be extremely difficult to assemble a test group of fleet vehicles in excess of about 10-15,000 vehicles. (Note: as part of a concurrent study for another client, HPI has estimated that there are only 60-70,000 light-duty vehicles - cars and trucks - in fleets of 20 vehicles or more in all of Canada.)

Further, the two year option indicates marginally lower costs for the low-end cost assumption and higher costs using the high-end assumptions. As noted in the previous chapters, the two year program increases the likelihood of serious participant biasing through drop-out. It is recommended that the shorter trial period be considered to avoid this problem.

FIGURE:5.3 DRL PROGRAM COSTS BY SAMPLE SIZE
(1 YEAR TRIAL)

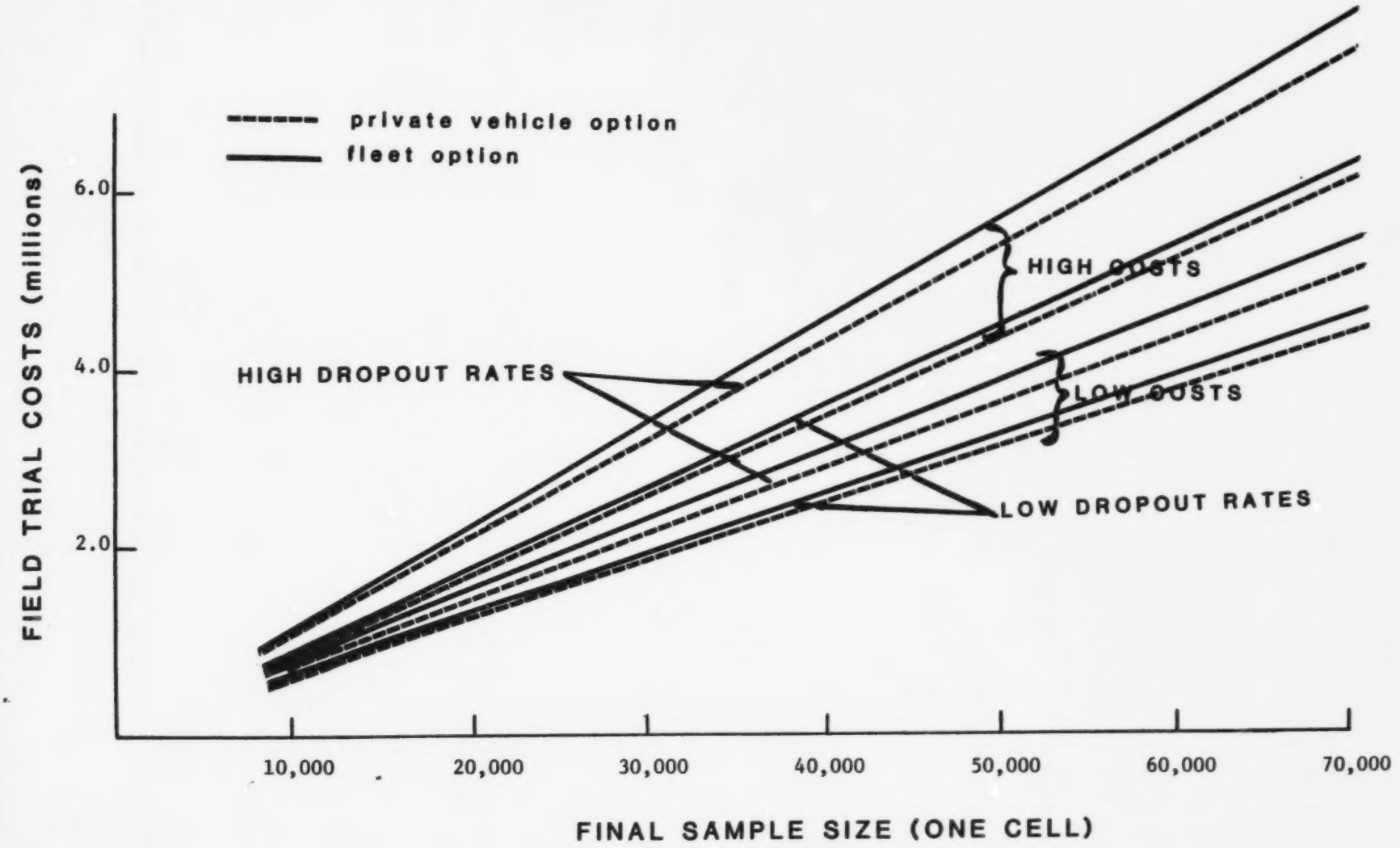


FIGURE 5.4: ONE YEAR DRL TRIAL COSTS BY STATISTICAL LEVEL

FLEET OPTION
LOW END COSTS

DRL PROJECT
1 YR TRIAL — COSTING EQUATION ($=A+B*INT CELL SIZE)
DROPOUT % 22 — A= 0.077 B= 0.04812

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	4.402	1.724	1.120	0.719
	0.30	38900	16600	9450	5850	2.477	1.101	0.660	0.436
	0.50	22800	9750	5610	3510	1.484	0.678	0.423	0.294
0.10	0.10	54000	22900	13100	8040	3.408	1.490	0.885	0.573
	0.30	27300	11700	6680	4160	1.761	0.799	0.489	0.334
	0.50	14200	6140	3570	2260	0.953	0.456	0.297	0.216
0.20	0.30	16700	7020	4000	2470	1.107	0.510	0.324	0.229
	0.50	6330	2670	1520	940	0.468	0.242	0.171	0.135

PRIVATE VEHICLES
LOW END COSTS

DRL PROJECT
1 YR TRIAL — COSTING EQUATION ($=A+B*INT CELL SIZE)
DROPOUT % 22 — A= 0.077 B= 0.04668

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	4.272	1.675	1.088	0.699
	0.30	38900	16600	9450	5850	2.405	1.070	0.643	0.427
	0.50	22800	9750	5610	3510	1.441	0.660	0.413	0.287
0.10	0.10	54000	22900	13100	8040	3.309	1.447	0.861	0.556
	0.30	27300	11700	6680	4160	1.711	0.777	0.477	0.326
	0.50	14200	6140	3570	2260	0.927	0.444	0.291	0.212
0.20	0.30	16700	7020	4000	2470	1.076	0.497	0.316	0.225
	0.50	6330	2670	1520	940	0.456	0.237	0.168	0.133

FIGURE 5.5: TWO YEAR DRL TRIAL COSTS BY STATISTICAL LEVEL

FLEET OPTION
LOW END COSTS

DRL PROJECT
2 YR TRIAL
DROPOUT % 22 PER YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.100 B= 0.06171

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	35050	13350	8450	5200	3.963	1.572	1.032	0.674
	0.30	19450	8300	4725	2925	2.244	1.015	0.621	0.423
	0.50	11400	4875	2805	1755	1.357	0.638	0.410	0.294
0.10	0.10	27000	11450	6550	4020	3.076	1.362	0.822	0.544
	0.30	13650	5850	3340	2080	1.605	0.745	0.469	0.330
	0.50	7100	3070	1785	1130	0.883	0.439	0.297	0.225
0.20	0.30	8350	3510	2000	1235	1.021	0.487	0.321	0.237
	0.50	3165	1335	760	470	0.449	0.248	0.184	0.152

PRIVATE VEHICLES
LOW END COSTS

DRL PROJECT
2 YR TRIAL
DROPOUT % 22 PER YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.094 B= 0.05668

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	35050	13350	8450	5200	3.642	1.445	0.949	0.620
	0.30	19450	8300	4725	2925	2.063	0.934	0.572	0.390
	0.50	11400	4875	2805	1755	1.248	0.587	0.378	0.272
0.10	0.10	27000	11450	6550	4020	2.827	1.253	0.757	0.501
	0.30	13650	5850	3340	2080	1.476	0.686	0.432	0.305
	0.50	7100	3070	1785	1130	0.813	0.405	0.275	0.208
0.20	0.30	8350	3510	2000	1235	0.939	0.449	0.296	0.219
	0.50	3165	1335	760	470	0.414	0.229	0.171	0.142

5.3 HBL COSTING

As with the DRL trial, HBL was costed based on a range of estimates of equipment unit costs, installation time and labour costs. The cost of the equipment was assumed to be equally divided between one and two-wire brake light systems. The range of fleet sizes used for cost estimation was representative of the sample sizes outlined in Chapter 4 and estimated drop-out rates. The cost estimates are plotted in Figure 5.6 for a range of sample sizes.

This Figure indicates that there is a cost difference between the private vehicle and the fleet options with the fleet option marginally more expensive. A range of cost assumptions (both capital and labour) were tested representing the extremes of costing assumptions. As with the DRL costing, it is doubtful that very large samples of fleet vehicles can be assembled and this option is restricted in its sample range. Further, the costing model assumes management time cost for the fleets - this may be volunteered by the participating fleets thus lowering the overall program cost.

It should also be noted that for the same sample size the HBL trial would be more expensive due to the higher equipment cost.

Using the sample size requirements of Figure 4.2, the range of drop-out rates and the sample size costs of Figure 5.6, a composite cost table (Figure 5.7) was developed. This table provides the estimated cost of a one year trial at the prescribed statistical levels for upper and lower bounds of cost assumptions and drop out rates.

Because of the lower sample size requirements (due to larger expected effects), only a one year trial was costed as the operational problems and drop-out rates in a two year program were judged not to warrant the slight reduction in trial costs achievable with a two year program.

Because of the relatively small sample size requirements, the fleet option was used as the basis for costing.

FIGURE:5.6 HBL PROGRAM COSTS BY SAMPLE SIZE
(1 YEAR TRIAL)

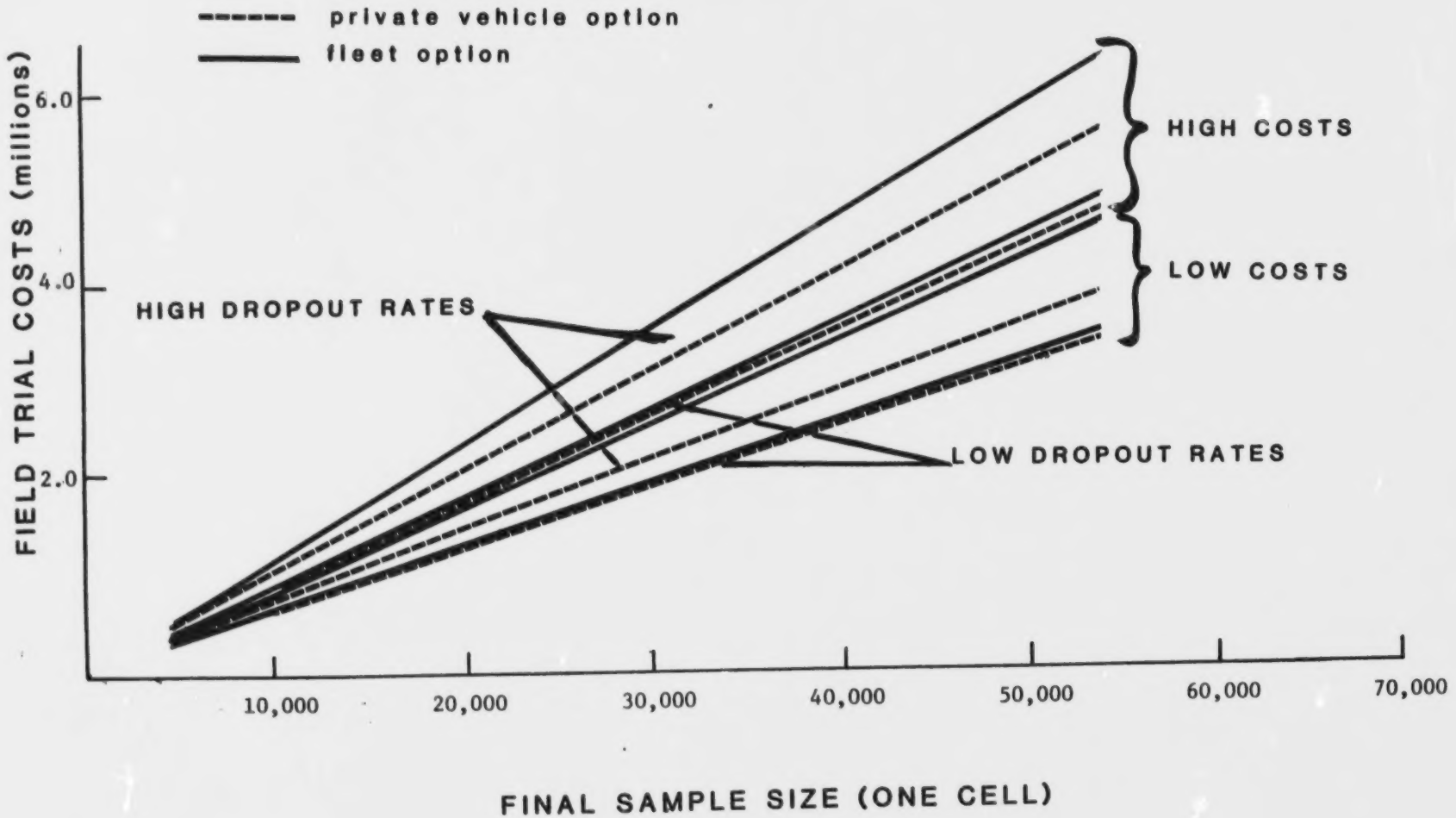


FIGURE 5.7: ONE YEAR HBL TRIAL COSTS BY STATISTICAL LEVEL

HBL PROJECT
1YR TRIAL — COSTING EQUATION ($=A+B*INT CELL SIZE)
DROPOUT % 22 — A= 0.077 — B= 0.06795

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	53400	5480	1810	3.371	0.415	0.189
	0.30	29600	3110	1050	1.903	0.269	0.142
	0.50	17300	1880	660	1.144	0.193	0.116
0.10	0.10	41200	4250	1420	2.619	0.339	0.165
	0.30	20600	2220	770	1.360	0.214	0.125
	0.50	10800	1220	450	0.743	0.152	0.105
0.20	0.30	12100	1340	490	0.823	0.160	0.107
	0.50	4600	510	190	0.361	0.108	0.089

PRIVATE VEHICLES
LOW END COSTS

HBL PROJECT
1YR TRIAL — COSTING EQUATION ($=A+B*INT CELL SIZE)
DROPOUT % 22 — A= 0.077 — B= 0.06651

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	53400	5480	1810	3.273	0.405	0.185
	0.30	29600	3110	1050	1.848	0.263	0.140
	0.50	17300	1880	660	1.112	0.190	0.114
0.10	0.10	41200	4250	1420	2.543	0.331	0.162
	0.30	20600	2220	770	1.322	0.210	0.123
	0.50	10800	1220	450	0.723	0.150	0.104
0.20	0.30	12100	1340	490	0.801	0.157	0.104
	0.50	4600	510	190	0.352	0.106	0.088

6.0 DESIGN RECOMMENDATIONS

Based on the foregoing analysis, the following recomendations for program design and cost estimates are offered.

6.1 DRL TRIAL

6.1.1 Lighting System

It is recommended that either increased wattage parking lights or reduced voltage headlights be used for the experiment. These two options have essentially the same initial costs (headlights have higher operating and maintenance costs). Depending on the expected standards, parking lights have a capability of using amber lenses where headlights do not. The DRL experiment should be separate from the HBL trial to avoid confounding the results.

6.1.2 Sample Fleet

The test vehicles should be drawn from the general automobile fleet due to both cost and logistical considerations. It would appear from this analysis that accident records would be available to track accident performance. Further, for the size of required test fleet, it becomes extremely difficult to assure that sufficient vehicles could be assembled under the commercial fleet option.

6.1.3 Geographic Location

It is recommended that the fleet be distributed throughout Canada, preferably in B.C., Saskatchewan, Manitoba or Quebec, where there are provincially-operated insurance schemes. The vehicles should be a low percentage of the total fleet to avoid any copying effects.

6.1.4 Statistical Measurement Limits

Based on the data reviewed and program costs developed, it is recommended that the experiment be constructed to test for a 15% effectiveness. This limit is set by the expected effect and is about the required effectiveness to justify the standard. It is recommended that statistical error limits of 0.1 and 0.3 for Type I and Type II errors be used as these represent 'normally' acceptable testing powers.

6.1.5 Length of Trial

While the project costs could be slightly reduced by opting for a two year program, there is less assurance that the costing is as accurate as the one year option due to unaccounted inflation. Further, the logistical problems of tracking the fleet for the longer time and sample biasing due to drop-out all argue against the two year program. Finally, results would not be available for 2½ to 3 years and thus any standard-setting would be further delayed by a year. On these bases, a one year trial is recommended as the most expeditious option for this experiment.

6.1.6 Program Cost

Based on these recommended design parameters and the project costing model, it is anticipated that a fleet of 30,000 to 37,000 would be required to assure final sample size after a one year trial (assumes 22% and 36% drop-out respectively). This size of test fleet would cost between $0.8 and $1.3 million. The high drop-out rates can be avoided with some screening and fleet deployment in the preferred provinces. Further, the high cost assumptions contained longer installation and removal time estimates and high equipment costs. If more probable values are used, the program costs are reduced to between $0.8 and $1.0 million, while still containing contingency funding.

6.2 HBL TRIAL

6.2.1 Equipment

HBL equipment is currently available from a number of sources, however the product selected must be designed to accommodate 'single wire' vehicles and allow for rapid installation, preferably on the exterior of the vehicle.

6.2.2 Sample Fleet

For the HBL fleet, the vehicles should be drawn from commerical fleet operators. The option is preferred in this case due to the smaller sample size and the logistical ease of extracting accident records.

6.2.3 Geographic Location

For this test, geographic location is not critical with the exception that test sites should be in the larger cities where traffic congestion (braking events) is higher. Also the larger cities will have larger fleet sizes thus reducing the number of companies required for participation.

6.2.4 Statistical Measurement Limits

As the prime goal of the dual-light test is to accept or reject its effectiveness with respect to the one light system (which has been shown to be approximately 50% effective), then the design limit for effectiveness should relate to how close to 50% is acceptable. It is recommended that a 30% effectiveness limit be used as a value which best represents the boundary acceptance effectiveness (it is well above the cost- effectiveness break-even point).

The statistical confidence limits required are recommended to be similar to the DRL trial - Type I = 0.1, Type II = 0.3.

6.2.5 Length of Trial

For this program there is no advantage to prolonging the trial. Thus, a one year period is recommended. In fact, it may be possible to reduce this period by monitoring the results on a quarterly basis and testing at the 50% effectiveness level.

6.2.6 Program Costs

Based on the above recommendations, the field trial program is estimated to require a total fleet size of between 5,700 and 7,300 depending on the drop- out rate assumed. At these fleet sizes, the program is estimated to cost between $210,000 and $330,000 with $210,000 to $270,000 being most probable. If a 50% effectiveness limit is used then these costs reduce to $130,000 to $170,00.

7.0 REFERENCES

1. R.E. Reilly, et.al., "Validation of the Reduction of Rear-end Collisions by a High-Mounted Auxillary Stoplamp", Allen Corp. DOT HS-805 360, US DOT, 1980, Washington.

2. III Research Institute, "Implementation Analysis for Daytime Use of Headlights", US DOT Contract No. DOT-HS-9-02112-9, Chicago, Ill, 1980.

3. Taylor, G.W., "An Evaluation of Automotive Lighting Systems and Accident Involvement", N.D. Lea and Assoc. Ltd., Transport Canada, 1979, Ottawa.

4. Conversation with Mr. J. Lawson, Transport Canada.

5. Kohl, J.S. and Baker, C. "Field Test Evaluation of Rear Lighting Sytems", Essex Corp. Report on Contract No. DOT-HS-01228, US DOT, 1978, Washington.

6. Conversations with Mr. A. Rausch of the Insurance Institute for Highway Safety on their DRL project and members of the contractors project team.

APPENDIX A

HBL DESCRIPTIVE MATERIAL

DON'T STOP UNTIL YOU GET ONE!

hi LITE

COLLISION AVOIDANCE LIGHT

LIMITED WARRANTY

[redacted]

[redacted]

2121 Cloverfield Blvd., Suite 131
Santa Monica, CA 90404

Here's How the HI-LITE Collision Avoidance Light Reduces Rear-End Accidents By 53%!

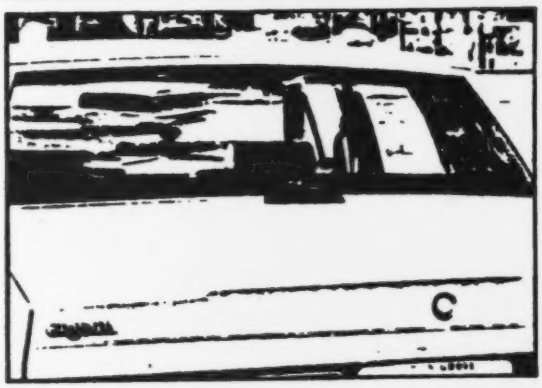
hi LITE

COLLISION AVOIDANCE LIGHT

[redacted]

It's easy to install

Complete do-it-yourself instructions are included with each unit. You can install your HI-LITE® in just minutes on most cars. For example, the only tool you need to install a HI-LITE® on a sedan is a pair of pliers to squeeze the wire clips together. HI-LITE® for hatchbacks and station wagons may take a little longer to install.



Thoroughly tested by the U.S. Government

How were the U.S. Government tests conducted?

The NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION (NHTSA) tests of the HI-LITE® were conducted during a two-year period on 7,400 vehicles driven more than 100 million miles.

Sooner or later almost every driver gets hit from the back

According to NHTSA, and the INSURANCE INSTITUTE FOR HIGHWAY SAFETY, rear-end collisions are the most common type of injury accident. About 30% of all accidents are rear-enders.

There are 4,300,000 rear-end collisions each year, or about eight per minute.

There are over one million whiplash injuries each year, and women are more likely to be injured in the rear-end accident; i.e., they are twice as likely to receive painful whiplash.

Amazing results

NHTSA reported that HI-LITE³ reduced rear-end accidents by an astounding 53%!

Traffic fatalities are seven times greater in night-time accidents, and that's when HI-LITE³ is even more effective.

The use of HI-LITE³ virtually eliminated nighttime rear-end accidents in the second major test.

Helps even more at night

During a one-year period, none of the cars equipped with HI-LITE³ were involved in rear-end collisions after dark, when most accidents usually occur.

From crashes to mere bumps

Where rear-end accidents did occur in cars equipped with HI-LITE³, damage and repair costs were nearly 60% less.

May be required on new cars

As a result of the government tests, the U.S. DEPARTMENT OF TRANSPORTATION has recommended that Collision Avoidance Lights become mandatory on all new cars sold in the United States. (Safety Standard No. 108, Proposed effective date: 9-1-83)

For more information, a summary of the U.S. Government test results and pending legislation is available from:

LASER CORP.
2121 Cloverfield Blvd., Suite 131
Santa Monica, CA 90404

Please enclose $1.00 for postage and handling.

A quality product

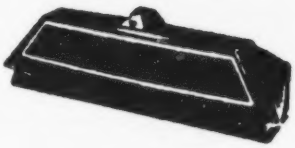
The HI-LITE³ and its special lens are made of durable high-impact polycarbonate. The light comes in popular contrasting black, currently used for most new car trim and accessories.

To match your car

The HI-LITE³ unit can easily be painted to match your car with automotive touch-up spray paint. The product carries a limited warranty.

SEDAN

HATCHBACK



STATION WAGON

A dramatic breakthrough

You may have seen on television or read in leading newspapers and magazines the news about the amazing new brake light that reduces rear-end collisions by more than half!

Proven by the Dept. of Transportation Tests

After two years of extensive testing by the U.S. Government, the phenomenal HI-LITE® Collision Avoidance Light is now available for your car.

Because this dramatic breakthrough in auto safety means proven protection for you, your family, and your car, you will want to know these important facts. . . .

A new kind of brake light

What is a Collision Avoidance Light?

The HI-LITE® Collision Avoidance Light is a third brake light designed to meet high photometric standards (SAE J186A).

It mounts on the trunk of your car just below the centerline of the rear window, at eye level to drivers behind you.

Eye level is the secret

The HI-LITE® is placed directly in the line of sight, right where drivers behind you are looking, through the windows of your car, as they watch traffic up ahead.

No confusion

And it is a clear, separate, stop signal — it can't be confused with the regular tail lights or turn indicators.

Helps prevent chain reaction accidents

Regular brake lights are only seen by the driver immediately behind you, whereas HI-LITE® can be seen, in most cases, through the windows of several cars behind you — helping to prevent chain reaction accidents.

"Tail Gaters" back off

It will help protect you from "tail gaters."

In fact, as soon as you install a HI-LITE® you will begin noticing cars stopping further back. When you touch your brakes, people behind you instantly see that you are stopping.

Better Depth Perception

Plus, when you're stopped at an intersection and your car is seen from some distance back, the HI-LITE® forms the apex of a triangle of brake lights that gives approaching drivers better depth perception.

APPENDIX B
DETAILED COST ESTIMATES

DRL FIELD TRIAL COSTING PROGRAM
REDUCED VOLTAGE HEADLIGHTS OR PARKING LIGHTS OPTION (2 year trial)

DESIGN VARIABLES

INITIAL SAMPLE SIZE:		COST ITEMS:	
CONTROL GRP=	20000	HARDWARE ($/unit)	15.00
EXPER GRP =	20000	INSTALL TIME (min)	15
TOTAL =	40000	REMOVE TIME (min)	5
		MECHANIC RATE ($/hr)	30.00

TASKS	GENERAL POPULATION OPTION				COMMERCIAL FLEET OPTION				LABOUR $
	P-DAYS	LAB $	CAP $	TOT $	P-DAYS	LAB $	CAP $	TOT $	$/P-DAY
1. TRIAL SET-UP									
1.1 sample access	25	9375	2000	11375	25	9375	2000	11375	375
1.2 records access	9	3375	2000	5375	9	3375	2000	5375	375
1.3 installation	30	11250	4000	15250	30	11250	4000	15250	375
2. SAMPLE SELECTION									
2.1 file forming	25	7500	8000	15500	25	7500	320	7820	300
2.2 initial screening	36	10800	120000	130800	100	30000	2400	32400	300
2.3 control acceptance	5	1500	20000	21500	40	12000	400	12400	300
2.4 exper acceptance	10	3000	20000	23000	200	60000	400	60400	300
3. HARDWARE INSTALLATION									
3.1 contractor coord	40	20000	5000	25000	100	50000	5000	55000	500
3.2 appointment mgnt	222	22222	0	22222	222	22222	0	22222	100
3.3 installation	667	150000	300000	450000	667	150000	300000	450000	225
3.4 repairs	100	22500	45000	67500	100	22500	45000	67500	225
3.5 removal	222	50000	0	50000	222	50000	0	50000	225
4. DATA ACQUISITION									
4.1 participation survey	170	51000	200000	251000	170	51000	200000	251000	300
4.2 forms retrieval	133	26667	800	27467	133	26667	800	27467	200
4.3 coding	133	20000	0	20000	133	20000	0	20000	150
4.4 data entry	1	375	800	1175	1	375	800	1175	375
4.5 data editing	4	1425	80	1505	4	1425	80	1505	375
5. TRIAL ANALYSIS									
5.1 statistical analysis	10	5000	1000	6000	10	5000	1000	6000	500
5.2 economic analysis	10	5000	500	5500	10	5000	500	5500	500
5.3 report preparation	10	5000	500	5500	10	5000	500	5500	500
6. PROJECT MANAGEMENT	210	126000	20000	146000	450	270000	31000	301000	600
TOTALS	2073	551989	749680	1301669	2662	812689	596200	1408889	

REDUCED VOLTAGE HEADLIGHTS OR PARKING LIGHTS OPTION (2 year trial)

DESIGN VARIABLES

INITIAL SAMPLE SIZE:		COST ITEMS:	
CONTROL GRP=	30000	HARDWARE ($/unit)	15.00
EXPER GRP =	30000	INSTALL TIME (min)	15
TOTAL =	60000	REMOVE TIME (min)	5
		MECHANIC RATE ($/hr)	30.00

TASKS	GENERAL POPULATION OPTION				COMMERCIAL FLEET OPTION				LABOUR $
	P-DAYS	LAB $	CAP $	TOT $	P-DAYS	LAB $	CAP $	TOT $	$/P-DAY
1. TRIAL SET-UP									
1.1 sample access	35	13125	2000	15125	35	13125	2000	15125	375
1.2 records access	11	4125	2000	6125	11	4125	2000	6125	375
1.3 installation	40	15000	4000	19000	40	15000	4000	19000	375
2. SAMPLE SELECTION									
2.1 file forming	25	7500	12000	19500	25	7500	480	7980	300
2.2 initial screening	44	13200	180000	193200	140	42000	3600	45600	300
2.3 control acceptance	5	1500	30000	31500	60	18000	600	18600	300
2.4 exper acceptance	10	3000	30000	33000	300	90000	600	90600	300
3. HARDWARE INSTALLATION									
3.1 contractor coord	60	30000	5000	35000	150	75000	5000	80000	500
3.2 appointment mgnt	333	33333	0	33333	333	33333	0	33333	100
3.3 installation	1000	225000	450000	675000	1000	225000	450000	675000	225
3.4 repairs	150	33750	67500	101250	150	33750	67500	101250	225
3.5 removal	333	75000	0	75000	333	75000	0	75000	225
4. DATA ACQUISITION									
4.1 participation survey	250	75000	300000	375000	250	75000	300000	375000	300
4.2 forms retrieval	200	40000	1200	41200	200	40000	1200	41200	200
4.3 coding	200	30000	0	30000	200	30000	0	30000	150
4.4 data entry	1	375	1200	1575	1	375	1200	1575	375
4.5 data editing	4	1575	120	1695	4	1575	120	1695	375
5. TRIAL ANALYSIS									
5.1 statistical analysis	10	5000	1000	6000	10	5000	1000	6000	500
5.2 economic analysis	10	5000	500	5500	10	5000	500	5500	500
5.3 report preparation	10	5000	500	5500	10	5000	500	5500	500
6. PROJECT MANAGEMENT	290	174000	28000	202000	650	390000	39000	429000	600
TOTALS	3022	790483	1115020	1905503	3913	1183783	879300	2063083	

DUAL HIGH-MOUNTED BRAKE LIGHTS (2 year trial)

DESIGN VARIABLES

INITIAL SAMPLE SIZE:		COST ITEMS:	
CONTROL GRP=	5000	HARDWARE ($/unit)	30.00
EXPER GRP =	5000	INSTALL TIME (min)	15
TOTAL =	10000	REMOVE TIME (min)	15
		MECHANIC RATE ($/hr)	30.00

TASKS	GENERAL POPULATION OPTION				COMMERCIAL FLEET OPTION				LABOUR $
	P-DAYS	LAB $	CAP $	TOT $	P-DAYS	LAB $	CAP $	TOT $	$/P-DAY
1. TRIAL SET-UP									
1.1 sample access	10	3750	2000	5750	10	3750	2000	5750	375
1.2 records access	6	2250	2000	4250	6	2250	2000	4250	375
1.3 installation	15	5625	4000	9625	15	5625	4000	9625	375
2. SAMPLE SELECTION									
2.1 file forming	25	7500	2000	9500	25	7500	40	7540	300
2.2 initial screening	24	7200	30000	37200	40	12000	600	12600	300
2.3 control acceptance	5	1500	5000	6500	10	3000	100	3100	300
2.4 exper acceptance	10	3000	5000	8000	50	15000	100	15100	300
3. HARDWARE INSTALLATION									
3.1 contractor coord	10	5000	5000	10000	25	12500	5000	17500	500
3.2 appointment mgnt	56	5556	0	5556	56	5556	0	5556	100
3.3 installation	167	37500	150000	187500	167	37500	150000	187500	225
3.4 repairs	25	5625	22500	28125	25	5625	22500	28125	225
3.5 removal	167	37500	0	37500	167	37500	0	37500	225
4. DATA ACQUISITION									
4.1 participation survey	50	15000	50000	65000	50	15000	50000	65000	300
4.2 forms retrieval	33	6667	200	6867	33	6667	200	6867	200
4.3 coding	33	5000	0	5000	33	5000	0	5000	150
4.4 data entry	1	375	200	575	1	375	200	575	375
4.5 data editing	3	1200	20	1220	3	1200	20	1220	375
5. TRIAL ANALYSIS									
5.1 statistical analysis	10	5000	1000	6000	10	5000	1000	6000	500
5.2 economic analysis	10	5000	500	5500	10	5000	500	5500	500
5.3 report preparation	10	5000	500	5500	10	5000	500	5500	500
6. PROJECT MANAGEMENT	90	54000	8000	62000	150	90000	19000	109000	600
TOTALS	760	219247	287920	507167	896	281047	257760	538807	

LOW END COSTS

L PROJECT
1 YR TRIAL — COSTING EQUATION ($=A+B*INT CELL SIZE)
DROPOUT % 22 — A= 0.077 — B= 0.04668

TYPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	15%	20%	25%	TRIAL COST IN MILLIONS$ 10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	4.272	1.675	1.088	0.699
	0.30	38900	16600	9450	5850	2.405	1.070	0.643	0.427
	0.50	22800	9750	5610	3510	1.441	0.660	0.413	0.287
0.10	0.10	54000	22900	13100	8040	3.309	1.447	0.861	0.556
	0.30	27300	11700	6680	4160	1.711	0.777	0.477	0.326
	0.50	14200	6140	3570	2260	0.927	0.444	0.291	0.212
0.20	0.30	16700	7020	4000	2470	1.076	0.497	0.316	0.225
	0.50	6330	2670	1520	940	0.456	0.237	0.168	0.133

L PROJECT
1YR TRIAL — COSTING EQUATION ($=A+B*INT CELL SIZE)
DROPOUT % 22 — A= 0.077 — B= 0.06651

TYPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	30%	50%	TRIAL COST IN MILLIONS$ 10%	30%	50%
0.05	0.10	53400	5480	1810	3.273	0.405	0.185
	0.30	29600	3110	1050	1.848	0.263	0.140
	0.50	17300	1880	660	1.112	0.190	0.116
0.10	0.10	41200	4250	1420	2.543	0.331	0.162
	0.30	20800	2220	770	1.322	0.210	0.123
	0.50	10800	1220	450	0.723	0.150	0.104
0.20	0.30	12100	1340	490	0.801	0.157	0.106
	0.50	4600	510	190	0.352	0.108	0.088

...ING : CELLS
LOW END COSTS

...L PROJECT
1 YR TRIAL
...OFOUT % 36

COSTING EQUATION ($=A+B$INT CELL SIZE)
A= 0.077 B= 0.04668

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	5.190	2.024	1.310	0.836
	0.30	38900	16600	9450	5850	2.914	1.288	0.766	0.504
	0.50	22800	9750	5610	3510	1.740	0.768	0.466	0.333
0.10	0.10	54000	22900	13100	8040	4.016	1.747	1.032	0.663
	0.30	27300	11700	6680	4160	2.068	0.930	0.564	0.360
	0.50	14200	6140	3570	2260	1.113	0.525	0.337	0.242
0.20	0.30	16700	7020	4000	2470	1.295	0.589	0.369	0.257
	0.50	6330	2670	1520	940	0.539	0.272	0.188	0.146

...L PROJECT
...R TRIAL
IRO:OUT % 36

COSTING EQUATION ($=A+B$INT CELL SIZE)
A= 0.077 B= 0.06651

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	53400	5480	1610	3.972	0.477	0.209
	0.30	29600	3110	1050	2.236	0.304	0.154
	0.50	17300	1880	660	1.339	0.214	0.125
0.10	0.10	41200	4250	1420	3.082	0.387	0.181
	0.30	20800	2220	770	1.594	0.239	0.133
	0.50	10800	1220	450	0.865	0.166	0.110
0.20	0.30	12100	1340	490	0.960	0.175	0.113
	0.50	4600	510	190	0.413	0.114	0.091

LECT OPTION
LOW END COSTS

RL PROJECT
1 YR TRIAL COSTING EQUATION (S=A+BXINT CELL SIZE)
THROUGHPUT % 22 A= 0.077 B= 0.04812

TYPE I ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	15%	20%	25%	TRIAL COST IN MILLIONS$ 10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	4.402	1.724	1.120	0.719
	0.30	38900	16600	9450	5850	2.477	1.101	0.666	0.430
	0.50	22800	9750	5610	3510	1.484	0.675	0.423	0.284
0.10	0.10	54000	22900	13100	8040	3.408	1.490	0.885	0.573
	0.30	27300	11700	6680	4160	1.761	0.799	0.487	0.334
	0.50	14290	6140	3570	2260	0.953	0.456	0.297	0.216
0.20	0.30	16700	7020	4000	2470	1.107	0.510	0.324	0.224
	0.50	8330	3670	1520	940	0.468	0.242	0.171	0.135

L PROJECT
1YR TRIAL COSTING EQUATION (S=A+B&INT CELL SIZE)
THROUGHPUT % 22 A= 0.077 B= 0.00795

TYPE I ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	30%	50%	TRIAL COST IN MILLIONS$ 10%	30%	50%
0.05	0.10	53400	5460	1810	3.371	0.415	0.159
	0.30	29600	3110	1050	1.903	0.269	0.142
	0.50	17300	1860	660	1.144	0.193	0.114
0.10	0.10	41200	4250	1420	2.619	0.339	0.165
	0.30	20800	2220	770	1.360	0.214	0.113
	0.50	10800	1220	450	0.743	0.152	0.105
0.20	0.30	12100	1340	490	0.823	0.160	0.107
	0.50	4600	510	190	0.361	0.108	0.089

...LL: OPTION
LOW END COSTS

...L PROJECT
1 YR TRIAL
DROPOUT % 39

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.077 B= 0.04812

TYPE I ERROR	TYPE II ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	5.607	2.183	1.410	0.897
	0.30	38900	16600	9450	5850	3.146	1.386	0.822	0.538
	0.50	22800	9750	5610	3510	1.876	0.846	0.520	0.354
0.10	0.10	54000	22900	13100	8040	4.337	1.883	1.110	0.711
	0.30	27300	11700	6680	4160	2.231	1.000	0.604	0.405
	0.50	14200	6140	3570	2260	1.197	0.561	0.359	0.255
0.20	0.30	16700	7020	4000	2470	1.394	0.631	0.393	0.272
	0.50	6330	2670	1520	940	0.576	0.288	0.197	0.151

...L PROJECT
...R TRIAL
DROPOUT % 39

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.077 B= 0.06795

TYPE I ERROR	TYPE II ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	53400	5460	1810	4.284	0.509	0.220
	0.30	29600	3110	1050	2.412	0.322	0.160
	0.50	17300	1860	660	1.442	0.225	0.129
0.10	0.10	41200	4250	1420	3.327	0.412	0.189
	0.30	20800	2220	770	1.718	0.252	0.138
	0.50	10800	1220	450	0.929	0.173	0.112
0.20	0.30	12100	1340	490	1.032	0.183	0.116
	0.50	4600	510	190	0.440	0.117	0.092

[illegible] OPTION
[illegible]ION END COSTS

[illegible]RL PROJECT
1 YR TRIAL — COSTING EQUATION ($=A+B*INT CELL SIZE)
[illegible]ROPOUT % 39 — A= 0.077 — B= 0.07045

[illegible]YPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	15%	20%	25%	TRIAL COST IN MILLIONS$ 10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	8.173	3.161	2.029	1.278
	0.30	38900	16600	9450	5850	4.570	1.994	1.168	0.753
	0.50	22800	9750	5610	3510	2.710	1.203	0.725	0.482
0.10	0.10	54000	22900	13100	8040	6.314	2.722	1.590	1.006
	0.30	27300	11700	6680	4160	3.230	1.428	0.848	0.557
	0.50	14200	6140	3570	2260	1.717	0.786	0.489	0.338
0.20	0.30	16700	7020	4000	2470	2.006	0.888	0.539	0.362
	0.50	6330	2670	1520	940	0.808	0.385	0.253	0.186

[illegible]L PROJECT
[illegible]YR TRIAL — COSTING EQUATION ($=A+B*INT CELL SIZE)
[illegible]ROPOUT % 39 — A= 0.077 — B= 0.09445

[illegible]YPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	30%	50%	TRIAL COST IN MILLIONS$ 10%	30%	50%
0.05	0.10	53400	5480	1810	6.244	0.710	0.284
	0.30	29600	3110	1050	3.496	0.436	0.198
	0.50	17300	1880	660	2.075	0.294	0.153
0.10	0.10	41200	4250	1420	4.835	0.568	0.241
	0.30	20800	2220	770	2.479	0.333	0.166
	0.50	10800	1220	450	1.324	0.218	0.129
0.20	0.30	12100	1340	490	1.474	0.232	0.134
	0.50	4600	510	190	0.608	0.136	0.099

[redacted]
HIGH END COSTS

[redacted]L PROJECT
1 YR TRIAL
DROPOUT Z 22

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.077 B= 0.07045

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10Z	15Z	20Z	25Z	10Z	15Z	20Z	25Z
0.05	0.10	70100	26700	16900	10400	6.408	2.489	1.603	1.016
	0.30	38900	16600	9450	5850	3.590	1.576	0.931	0.605
	0.50	22800	9750	5610	3510	2.136	0.958	0.584	0.394
0.10	0.10	54000	22900	13100	8040	4.954	2.145	1.260	0.803
	0.30	27300	11700	6680	4160	2.543	1.134	0.680	0.453
	0.50	14200	6140	3570	2260	1.360	0.632	0.399	0.281
0.20	0.30	16700	7020	4000	2470	1.585	0.711	0.438	0.300
	0.50	6330	2670	1520	940	0.649	0.318	0.214	0.162

[redacted]L PROJECT
[redacted]R TRIAL
DROPOUT Z 22

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.077 B= 0.09445

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10Z	30Z	50Z	10Z	30Z	50Z
0.05	0.10	53400	5480	1810	4.900	0.572	0.240
	0.30	29600	3110	1050	2.750	0.358	0.172
	0.50	17300	1880	660	1.640	0.247	0.137
0.10	0.10	41200	4250	1420	3.798	0.461	0.205
	0.30	20800	2220	770	1.956	0.278	0.147
	0.50	10800	1220	450	1.052	0.187	0.118
0.20	0.30	12100	1340	490	1.170	0.196	0.121
	0.50	4600	510	190	0.492	0.123	0.094

[illegible]
HIGH END COSTS

[illegible] PROJECT
1 YR TRIAL
DROPOUT % 36

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.077 B= 0.0690

TYPE I ERROR	TYPE II ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	7.636	2.956	1.899	1.198
	0.30	38900	16600	9450	5850	4.272	1.867	1.096	0.708
	0.50	22800	9750	5610	3510	2.535	1.128	0.682	0.455
0.10	0.10	54000	22900	13100	8040	5.900	2.546	1.490	0.944
	0.30	27300	11700	6680	4160	3.021	1.339	0.797	0.526
	0.50	14200	6140	3570	2260	1.608	0.739	0.462	0.321
0.20	0.30	16700	7020	4000	2470	1.878	0.834	0.508	0.343
	0.50	6330	2670	1520	940	0.760	0.365	0.241	0.178

[illegible] PROJECT
[illegible] TRIAL
DROPOUT % 36

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.077 B= 0.0930

TYPE I ERROR	TYPE II ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	53400	5480	1810	5.835	0.668	0.272
	0.30	29600	3110	1050	3.269	0.412	0.190
	0.50	17300	1880	660	1.942	0.280	0.148
0.10	0.10	41200	4250	1420	4.520	0.535	0.230
	0.30	20800	2220	770	2.320	0.316	0.160
	0.50	10800	1220	450	1.242	0.209	0.126
0.20	0.30	12100	1340	490	1.382	0.221	0.130
	0.50	4600	510	190	0.573	0.132	0.097

HIGH END COSTS

RL PROJECT
1 YR TRIAL
DROPOUT % 22

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.077 B= 0.06901

TYPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	15%	20%	25%	TRIAL COST IN MILLIONS$ 10%	15%	20%	25%
0.05	0.10	70100	26700	16900	10400	6.279	2.439	1.572	0.997
	0.30	38900	16600	9450	5850	3.519	1.546	0.913	0.595
	0.50	22800	9750	5610	3510	2.094	0.940	0.573	0.368
0.10	0.10	54000	22900	13100	8040	4.855	2.103	1.236	0.788
	0.30	27300	11700	6680	4160	2.492	1.112	0.668	0.445
	0.50	14200	6140	3570	2260	1.333	0.620	0.393	0.277
0.20	0.30	16700	7020	4000	2470	1.555	0.698	0.431	0.296
	0.50	6330	2670	1520	940	0.637	0.313	0.211	0.160

RL PROJECT
1 YR TRIAL
DROPOUT % 22

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.077 B= 0.09301

TYPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	30%	50%	TRIAL COST IN MILLIONS$ 10%	30%	50%
0.05	0.10	53400	5480	1810	4.802	0.562	0.237
	0.30	29600	3110	1050	2.696	0.352	0.170
	0.50	17300	1880	660	1.608	0.243	0.135
0.10	0.10	41200	4250	1420	3.722	0.453	0.203
	0.30	20800	2220	770	1.917	0.273	0.145
	0.50	10800	1220	450	1.033	0.185	0.117
0.20	0.30	12100	1340	490	1.148	0.196	0.120
	0.50	4600	510	190	0.484	0.122	0.094

...VATE VEHICLES
...GH END COSTS

...L PROJECT
2 YR TRIAL
...ROPOUT % 36
...R YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.094 B= 0.07976

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	35050	13350	8450	5200	10.078	3.897	2.501	1.575
	0.30	19450	8300	4725	2925	5.634	2.458	1.440	0.927
	0.50	11400	4875	2805	1755	3.341	1.483	0.893	0.594
0.10	0.10	27000	11450	6550	4020	7.785	3.356	1.960	1.239
	0.30	13650	5850	3340	2080	3.982	1.760	1.045	0.687
	0.50	7100	3070	1785	1130	2.116	0.969	0.602	0.416
0.20	0.30	8350	3510	2000	1235	2.473	1.094	0.664	0.446
	0.50	3165	1335	760	470	0.996	0.474	0.310	0.228

...L PROJECT
...YR TRIAL
...ROPOUT % 36
...R YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.076 B= 0.10467

TYPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	26700	2740	905	7.700	0.875	0.352
	0.30	14800	1555	525	4.310	0.537	0.244
	0.50	8650	940	330	2.558	0.362	0.188
0.10	0.10	20600	2125	710	5.962	0.699	0.296
	0.30	10400	1110	385	3.057	0.410	0.204
	0.50	5400	610	225	1.632	0.268	0.158
0.20	0.30	6050	670	245	1.817	0.285	0.164
	0.50	2300	255	95	0.749	0.167	0.121

[illegible]
HIGH END COSTS

[illegible]RL PROJECT
2 YR TRIAL
[illegible]ROPOUT Z 39 COSTING EQUATION ($=A+B*INT CELL SIZE)
[illegible]ER YR A= 0.100 B= 0.08479

[illegible]PE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	35050	13350	8450	5200	13.610	5.246	3.357	2.105
	0.30	19450	8300	4725	2925	7.597	3.300	1.922	1.228
	0.50	11400	4875	2805	1755	4.494	1.979	1.182	0.777
0.10	0.10	27000	11450	6550	4020	10.507	4.514	2.625	1.650
	0.30	13650	5850	3340	2080	5.362	2.355	1.388	0.902
	0.50	7100	3070	1785	1130	2.837	1.284	0.788	0.536
0.20	0.30	8350	3510	2000	1235	3.319	1.453	0.871	0.577
	0.50	3165	1335	760	470	1.320	0.615	0.393	0.282

[illegible]L PROJECT
2 YR TRIAL
[illegible]ROPOUT Z 39 COSTING EQUATION ($=A+B*INT CELL SIZE)
[illegible]R YR A= 0.078 B= 0.10976

[illegible]PE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	26700	2740	905	10.392	1.157	0.449
	0.30	14800	1555	525	5.805	0.700	0.303
	0.50	8650	940	330	3.434	0.463	0.228
0.10	0.10	20600	2125	710	8.040	0.920	0.374
	0.30	10400	1110	385	4.109	0.528	0.249
	0.50	5400	610	225	2.182	0.336	0.187
0.20	0.30	6050	670	245	2.432	0.359	0.195
	0.50	2300	255	95	0.987	0.199	0.137

[illegible] OF [illegible]
HIGH END COSTS

[illegible]L PROJECT
2 YR TRIAL
[illegible]ROPOUT % 22
[illegible]R YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.100 B= 0.08479

[illegible]PE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	35050	13350	6450	5200	5.408	2.122	1.380	0.888
	0.30	19450	8300	4725	2925	3.046	1.357	0.816	0.543
	0.50	11400	4875	2805	1755	1.827	0.839	0.525	0.366
0.10	0.10	27000	11450	6550	4020	4.189	1.834	1.092	0.709
	0.30	13650	5850	3340	2080	2.167	0.986	0.606	0.415
	0.50	7100	3070	1785	1130	1.176	0.565	0.371	0.272
0.20	0.30	8350	3510	2000	1235	1.365	0.632	0.403	0.288
	0.50	3165	1335	760	470	0.580	0.303	0.216	0.172

[illegible]L PROJECT
2 YR TRIAL
DROPOUT % 22
[illegible]R YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.078 B= 0.10976

[illegible]PE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	26700	2740	905	4.143	0.515	0.238
	0.30	14800	1555	525	2.342	0.336	0.180
	0.50	8650	940	330	1.410	0.243	0.150
0.10	0.10	20600	2125	710	3.220	0.422	0.208
	0.30	10400	1110	385	1.675	0.269	0.159
	0.50	5400	610	225	0.918	0.193	0.135
0.20	0.30	6050	670	245	1.017	0.202	0.138
	0.50	2300	255	95	0.449	0.139	0.115

[illegible] OF FLOW
[illegible]W END COSTS

[illegible]L PROJECT
2 YR TRIAL
[illegible]OPOUT % 22
[illegible]R YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.100 B= 0.06171

[illegible]PE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE 10%	15%	20%	25%	TRIAL COST IN MILLIONS$ 10%	15%	20%	25%
0.05	0.10	35050	13350	8450	5200	3.963	1.572	1.032	0.674
	0.30	19450	8300	4725	2925	2.244	1.015	0.621	0.423
	0.50	11400	4875	2805	1755	1.357	0.638	0.410	0.294
0.10	0.10	27000	11450	6550	4020	3.076	1.362	0.822	0.544
	0.30	13650	5850	3340	2080	1.605	0.745	0.469	0.330
	0.50	7100	3070	1785	1130	0.883	0.439	0.297	0.225
0.20	0.30	8350	3510	2000	1235	1.021	0.487	0.321	0.237
	0.50	3165	1335	760	470	0.449	0.248	0.184	0.152

[illegible]L PROJECT
[illegible]YR TRIAL
[illegible]ROPOUT % 22
[illegible]R YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.078 B= 0.06251

[illegible]PE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE 10%	30%	50%	TRIAL COST IN MILLIONS$ 10%	30%	50%
0.05	0.10	26700	2740	905	3.043	0.402	0.200
	0.30	14800	1555	525	1.732	0.272	0.156
	0.50	8650	940	330	1.054	0.204	0.137
0.10	0.10	20600	2125	710	2.371	0.335	0.179
	0.30	10400	1110	385	1.247	0.223	0.143
	0.50	5400	610	225	0.696	0.168	0.125
0.20	0.30	6050	670	245	0.767	0.174	0.128
	0.50	2300	255	95	0.354	0.129	0.111

COW END COSTS

L PROJECT
2 YR TRIAL
OPOUT % 39
R YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.100 B= 0.06171

PE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	35050	13350	8450	5200	9.933	3.845	2.471	1.559
	0.30	19450	8300	4725	2925	5.557	2.429	1.426	0.921
	0.50	11400	4875	2805	1755	3.298	1.468	0.887	0.593
0.10	0.10	27000	11450	6550	4020	7.675	3.312	1.938	1.228
	0.30	13650	5850	3340	2080	3.930	1.742	1.037	0.684
	0.50	7100	3070	1785	1130	2.092	0.962	0.601	0.417
0.20	0.30	8350	3510	2000	1235	2.443	1.085	0.662	0.447
	0.50	3165	1335	760	470	0.988	0.475	0.314	0.232

L PROJECT
2-YR TRIAL
DROPOUT % 39
R YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.078 B= 0.08251

YPE 1 ERROR	TYPE 11 ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	26700	2740	905	7.590	0.869	0.354
	0.30	14800	1555	525	4.252	0.537	0.248
	0.50	6650	940	330	2.527	0.364	0.193
0.10	0.10	20600	2125	710	5.879	0.697	0.300
	0.30	10400	1110	385	3.018	0.412	0.209
	0.50	5400	610	225	1.615	0.272	0.164
0.20	0.30	6050	670	245	1.798	0.288	0.169
	0.50	2300	255	95	0.746	0.172	0.127

[illegible]
LOW END COSTS

[illegible]L PROJECT
2 YR TRIAL
DROPOUT % 22
ER YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.094 B= 0.05668

TYPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE				TRIAL COST IN MILLIONS$			
		10%	15%	20%	25%	10%	15%	20%	25%
0.05	0.10	35050	13350	6450	5200	3.642	1.445	0.949	0.620
	0.30	19450	8300	4725	2925	2.063	0.934	0.572	0.390
	0.50	11400	4875	2805	1755	1.248	0.567	0.378	0.272
0.10	0.10	27000	11450	6550	4020	2.827	1.253	0.757	0.501
	0.30	13650	5650	3340	2080	1.476	0.686	0.432	0.305
	0.50	7100	3070	1785	1130	0.813	0.405	0.275	0.208
0.20	0.30	8350	3510	2000	1235	0.939	0.449	0.296	0.219
	0.50	3165	1335	760	470	0.414	0.229	0.171	0.142

[illegible]L PROJECT
YR TRIAL
DROPOUT % 22
ER YR

COSTING EQUATION ($=A+B*INT CELL SIZE)
A= 0.078 B= 0.07742

TYPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE			TRIAL COST IN MILLIONS$		
		10%	30%	50%	10%	30%	50%
0.05	0.10	26700	2740	905	2.796	0.371	0.186
	0.30	14800	1555	525	1.592	0.251	0.147
	0.50	8650	940	330	0.970	0.189	0.127
0.10	0.10	20600	2125	710	2.179	0.309	0.166
	0.30	10400	1110	385	1.147	0.206	0.133
	0.50	5400	610	225	0.641	0.156	0.117
0.20	0.30	6050	670	245	0.706	0.162	0.119
	0.50	2300	255	95	0.327	0.120	0.104

...AIR VEHICLES
LOW END COSTS

...L PROJECT
2 YR TRIAL COSTING EQUATION ($=A+B*INT CELL SIZE)
...ROPOUT % 36 A= 0.094 B= 0.05668
...R YR

TYPE I ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	15%	20%	25%	TRIAL COST IN MILLIONS$ 10%	15%	20%	25%
0.05	0.10	35050	13350	8450	5200	7.189	2.796	1.805	1.147
	0.30	19450	8300	4725	2925	4.031	1.774	1.050	0.686
	0.50	11400	4675	2805	1755	2.402	1.081	0.662	0.449
0.10	0.10	27000	11450	6550	4020	5.560	2.412	1.420	0.906
	0.30	13650	5850	3340	2080	2.857	1.278	0.770	0.515
	0.50	7100	3070	1785	1130	1.531	0.715	0.455	0.323
0.20	0.30	8350	3510	2000	1235	1.784	0.805	0.499	0.344
	0.50	3165	1335	760	470	0.735	0.364	0.248	0.189

...L PROJECT
...YR TRIAL COSTING EQUATION ($=A+B*INT CELL SIZE)
DROPOUT % 36 A= 0.078 B= 0.07742
...R YR

TYPE I ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	30%	50%	TRIAL COST IN MILLIONS$ 10%	30%	50%
0.05	0.10	26700	2740	905	5.499	0.649	0.277
	0.30	14800	1555	525	3.090	0.409	0.200
	0.50	8650	940	330	1.845	0.284	0.161
0.10	0.10	20600	2125	710	4.264	0.524	0.238
	0.30	10400	1110	385	2.199	0.319	0.172
	0.50	5400	610	225	1.187	0.217	0.140
0.20	0.30	6050	670	245	1.319	0.230	0.144
	0.50	2300	255	95	0.560	0.146	0.113

[illegible]
[illegible] END COSTS

[illegible] PROJECT
2 YR TRIAL COSTING EQUATION ($=A+B*INT CELL SIZE)
[illegible]ROPOUT % 22 A= 0.094 B= 0.07976
[illegible] YR

TYPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	15%	20%	25%	TRIAL COST IN MILLIONS$ 10%	15%	20%	25%
0.05	0.10	35050	13350	8450	5[illegible]0	5.086	1.995	1.298	0.865
	0.30	19450	8300	4725	2925	2.864	1.276	0.767	0.511
	0.50	11400	4875	2805	1755	1.718	0.788	0.494	0.344
0.10	0.10	27000	11450	6550	4020	3.940	1.725	1.027	0.667
	0.30	13650	5850	3340	2080	2.038	0.927	0.570	0.390
	0.50	7100	3070	1785	1130	1.105	0.531	0.348	0.255
0.20	0.30	8350	3510	2000	1235	1.263	0.594	0.379	0.270
	0.50	3165	1335	760	470	0.545	0.284	0.202	0.161

[illegible] PROJECT
[illegible]YR TRIAL COSTING EQUATION ($=A+B*INT CELL SIZE)
[illegible]ROPOUT % 22 A= 0.078 B= 0.10467
[illegible] YR

TYPE 1 ERROR	TYPE II ERROR	FINAL CELL SIZE 10%	30%	50%	TRIAL COST IN MILLIONS$ 10%	30%	50%
0.05	0.10	26700	2740	905	3.897	0.484	0.223
	0.30	14800	1555	525	2.202	0.315	0.169
	0.50	8650	940	330	1.326	0.228	0.141
0.10	0.10	20600	2125	710	3.028	0.397	0.195
	0.30	10400	1110	385	1.575	0.252	0.149
	0.50	5400	610	225	0.863	0.181	0.126
0.20	0.30	6050	670	245	0.956	0.189	0.129
	0.50	2300	255	95	0.422	0.130	0.108

APPENDIX C

COST MODEL PROGRAM LISTING

```
A1        = "HICKLING-PARTNERS INC.
A2        = "PROJECT #1097
A11        = "DRL FIELD TRIAL COSTING PROGRAM
C12        = "REDUCED VOLTAGE HEADLIGHTS OR PARKING LIGHTS OPTION (1 year trial)
A14        = "DESIGN VARIABLES
A15        = "==========================
B15        = "==============================
C16        = "INITIAL SAMPLE SIZE:
A16        = "COST ITEMS:
A17        = "-------------------------
G17        = "-------------------------------
A16        = "CONTROL GRP=
B16        = 0
G16        = "HARDWARE ($/unit)
F16 $      = 15
A19        = "EXPER GRP  =
E19        = C
G19        = "INSTALL TIME (min)
B19        = 15
A20        = "TOTAL      =
E20        = SUM(E16:E19)
A20        = "REMOVE TIME (min)
B20        = 5
C21        = "==========================
G21        = "MECHANIC RATE ($/hr
B21 $      = 30
C22        = "==============================
I22 G      = "=========
A24        = "============================
B24        = "==========
D24        = "==========
E24        = "==========
F24        = "=========
G24        = "============
H24        = "==========
I24        = "==========
J24        = "=========
K24        = "=========
L24        = "=========
A25        = "   GENERAL POPULATION OPTION
G25        = "      COMMERCIAL FLEET OPTION
L25 TR     = "LABOUR $
A26        = "    TASKS
C26        = "   ------
D26        = "---------
E26        = "---------
F26        = "---------
G26        = "      ---------
H26        = "---------
I26        = "---------
J26        = "---------
L26        = "---------
A27 TR     = "P-DAYS
D27 TR     = "LAB $
E27 TR     = "CAP $
```

```
[illegible] TR    = '--DAYS
H27 TR    = "LAB $
127 TR    = "CAP $
[illegible]27 TR  = "TOT $
427 TR    = "$/P-DAY
B28       = "==========
[illegible]28       = "==========
[illegible]28       = "==========
E28       = "==========
F28       = "==========
[illegible]28       = "==========
H28       = "==========
I28       = "==========
[illegible]28       = "==========
[illegible]28       = "==========
L28       = "==========
B30       = "1. TRIAL SET-UP
[illegible]31       = "1.1 sample access
C31       = 5+5*E20/10000
D31       = C31*L31
[illegible]31       = 2000
F31       = SUM(D31:E31)
G31       = 5+5*E20/10000
[illegible]31       = G31*L31
[illegible]31       = 2000
J31       = SUM(H31:I31)
L31       = 375
[illegible]32       = "1.2 records access
C32       = 5+1*E20/10000
D32       = C32*L32
[illegible]32       = 2000
F32       = SUM(D32:E32)
G32       = 5+1*E20/10000
[illegible]32       = G32*L32
[illegible]32       = 2000
J32       = SUM(H32:I32)
[illegible]32       = 375
B33       = "1.3 installation
C33       = 10+5*E20/10000
D33       = C33*L33
[illegible]33       = 4000
F33       = SUM(D33:E33)
G33       = 10+5*E20/10000
[illegible]33       = G33*L33
[illegible]33       = 4000
J33       = SUM(H33:I33)
[illegible]33       = 375
[illegible]36       = "2. SAMPLE SELECTION
B37       = "2.1 file loading
C37       = 5*5
D37       = C37*L37
E37       = E20*2*0.1
F37       = SUM(D37:E37)
G37       = 5*5
H37       = G37*L37
I37       = E20*2*0.2/50
J37       = SUM(H37:I37)
L37       = 300
B38       = "2.2 initial screening
C38       = 20+E20*2/5000
D38       = C36*L38
E38       = E20*2*1.5
```

```
[illegible]  = SUM(D36:E36
G36          = 20+E20*2*.05/50
H36          = G36*L36
[illegible]  = E20*2*1.5/50
[illegible]  = SUM(H36:I36)
L36          = 300
[illegible]  = "2.3 control acceptance
[illegible]  = 5
D39          = C39*L39
E39          = E18*1.
[illegible]  = SUM(D39:E39)
G39          = .1*E18/50
H39          = G39*L39
[illegible]  = E18*1./50
[illegible]  = SUM(H39:I39)
L39          = 300
[illegible]  = "2.4 exper acceptance
[illegible]  = 10
D40          = C40*L40
E40          = E19*1.
[illegible]  = SUM(D40:E40)
G40          = .5*E19/50
H40          = G40*L40
[illegible]  = E19*1./50
[illegible]  = SUM(H40:I40)
L40          = 300
[illegible]  = "3. HARDWARE INSTALLATION
[illegible]  = "3.1 contractor coord
C44          = E19*2/1000
D44          = C44*L44
[illegible]  = 5000
[illegible]  = SUM(D44:E44)
G44          = E19*.25/50
[illegible]  = G44*L44
[illegible]  = 5000
J44          = SUM(H44:I44)
L44          = 500
[illegible]  = "3.2 appointment cont
C45          = E19*5/450
D45          = C45*L45
[illegible]  = 0
F45          = SUM(D45:E45)
G45          = E19*5/450
[illegible]  = G45*L45
[illegible]  = 0
J45          = SUM(H45:I45)
L45          = 100
[illegible]  = "3.3 installation
C46          = E19*19/450
D46          = C46*L46
E46          = E19*18
F46          = SUM(D46:E46)
G46          = E19*19/450
H46          = G46*L46
I46          = E19*18
J46          = SUM(H46:I46)
L46          = 7.5*21
B47          = "3.4 repairs
C47          = .1*C46
D47          = C47*L47
E47          = 0.1*E46
F47          = SUM(D47:E47)
G47          = .1*G46
```

```
[illegible]
[illegible]7      = J.1*E4*C
J47       = SUM(M7:I47)
L47       = 7.5*I2%
[illegible]48      = "3.5 removal
C48       = E19*I20/450
D48       = C48*L48
[illegible]48      = 0
[illegible]48      = SUM(D48:E48)
G48       = E19*I20/450
[illegible]48      = G48*L48
[illegible]48      = 0
J48       = SUM(M48:I48)
L48       = 7.5*I2%
[illegible]51      = "4. DATA ACQUISITION
[illegible]52      = "4.1 participation survey
C52       = 10+E20*1/500
[illegible]52      = C52*L52
[illegible]52      = E20*1*2.5
F52       = SUM(D52:E52)
G52       = 10+E20*1/500
[illegible]52      = G52*L52
[illegible]52      = E20*1*2.5
J52       = SUM(H52:I52)
[illegible]52      = 300
[illegible]53      = "4.2 forms retrieval
C53       = E20*.1*15/450
[illegible]53      = C53*L53
[illegible]53      = .1*E20*.2
F53       = SUM(D53:E53)
G53       = E20*.1*15/450
[illegible]53      = G53*L53
[illegible]53      = .1*E20*.2
J53       = SUM(M53:I53)
[illegible]53      = 200
[illegible]54      = "4.3 coding
C54       = E20*.1*15/450
[illegible]54      = C54*L54
[illegible]54      = 0
F54       = SUM(D54:E54)
G54       = E20*.1*15/450
[illegible]54      = G54*L54
[illegible]54      = 0
J54       = SUM(M54:I54)
[illegible]54      = 150
[illegible]55      = "4.4 data entry
C55       = 1
[illegible]55      = C55*L55
[illegible]55      = 200*E20*.1/1000
F55       = SUM(D55:E55)
G55       = 1
[illegible]55      = G55*L55
[illegible]55      = 200*E20*.1/1000
J55       = SUM(M55:I55)
[illegible]55      = 375
[illegible]56      = "4.5 data editing
C56       = 3+E20*1*.1/5000
[illegible]56      = C56*L56
[illegible]56      = E20*.1*20/1000
F56       = SUM(D56:E56)
G56       = 3+E20*1*.1/5000
[illegible]56      = G56*L56
[illegible]56      = E20*.1*20/1000
```

```
B58     = 30
B59     = "5. TRIAL ANALYSIS
B60     = "5.1 statistical analysis
C60     = 10
D60     = C60*L60
E60     = 1000
F60     = SUM(D60:E60)
G60     = 10
H60     = G60*L60
I60     = 1000
J60     = SUM(H60:I60)
K60     = 500
B61     = "5.2 economic analysis
C61     = 10
D61     = C61*L61
E61     = 500
F61     = SUM(D61:E61)
G61     = 10
H61     = G61*L61
I61     = 500
J61     = SUM(H61:I61)
K61     = 500
B62     = "5.3 report preparation
C62     = 10
D62     = C62*L62
E62     = 500
F62     = SUM(D62:E62)
G62     = 10
H62     = G62*L62
I62     = 500
J62     = SUM(H62:I62)
K62     = 500
B63     = "6. PROJECT MANAGEMENT
C63     = 25+E22*.25
D63     = C63*L63
E63     = 2000+E22*1000 500
F63     = SUM(D63:E63)
G63     = 25+E22*.25/50
H63     = G63*L63
I63     = 750+E22*1000/5000
J63     = SUM(H63:I63)
K63     = 600
B66     = "-------------------------
C66     = "---------
D66     = "---------
E66     = "---------
F66     = "---------
G66     = "      ------
H66     = "---------
I66     = "---------
J66     = "---------
K66     = "---------
B67     = "  TOTALS
C67     = SUM(C30:C65)
D67     = SUM(D30:D65)
E67     = SUM(E30:E65)
F67     = SUM(F30:F65)
G67     = SUM(G30:G65)
H67     = SUM(H30:H65)
I67     = SUM(I30:I65)
J67     = SUM(J30:J65)
K68     = "=========================
```

POOR

QUALITY

ORIGINAL